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Attorney for Plaintiff

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF PENNSYLVANIA

ROBERT J. KRAUS and MARGARET M. KRAUS, h/w	:CIVIL ACTION :
vs.	:NO. 18-CV-2119
ALCATEL-LUCENT, et al.	:ASBESTOS CASE

ANSWER TO SPACE/SYSTEMS LORAL MOTION TO EXCLUDE DR. FRANK

This motion is the same as the Honeywell motion and that of others therefore should similarly be denied.

PAUL, REICH & MYERS, P.C.

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ROBERT E. PAUL

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MEMORANDUM

As with the motions of the others movant is engaged in a theoretical and sterile discussion about each and every breath contributing to disease which is both generally accepted (Exhibit G) and irrelevant to this case. It should be discussing the actual testimony that will be given based on the evidence of years of exposure to Ford and Philco asbestos[1]. Space Systems' motion is copied almost word for word from GE's and Honeywell's motions. Pursuant to rule 10(c) the answers to those motions are incorporated by reference. Space Systems, like the other defendants, harps on the assertion that Dr. Frank will give each and every exposure testimony which is directly contrary to what he is going to testify.

In fact, as all well know he will follow F.R.Evid 703 and the Federal Court Reference Manual. Based on the testimony of years of exposure to Ford and/or Philco asbestos from the witnesses he will opine that years of exposure to asbestos from Ford and/or Philco asbestos

[1] One of the issues on Space Systems motion for summary judgment is whether it or Ford is liable for the Philco Ford equipment on the USS Cambria. For this motion it is assumed Space Systems is the liable entity.

caused the injury. Space Systems appears to have the liability for Ford and Philco according to Ford. This is the subject of different motions.

As noted in response to the motions of other defendants, Space Systems, focusus on Dr. Frank's beliefs and prior testimony not upon what they know he will say in this case and it ignores the most relevant cases *Rost v. Ford*, 151 A.3d 1052 and Mortimer.

Space Systems acquired the business that had formerly been conducted by Philco, later by Ford. Ford sold the business to Space Systems. During the time that Kraus served on the ship there were numerous pieces of electronic equipment (Exhibit A, NT 60). This equipment was opened up and repaired on a regular scheduled basis as part of preventative maintenance throughout his 3 years on the ship. (Exhibit A, NT 60). Kraus was present when the equipment was opened and had to be vacuumed out releasing dust he inhaled (Exhibit B, NT 30). Ford and its predecessor Philco had a large number of pieces of equipment on the ship in the electronic shop (Exhibit C). The coworker recalled Ford equipment in the shop (Exhibit A) and noted that every piece of electronic equipment contained resistors and capacitors and wire (Exhibit D). Navy documents and patents and National Bureau of Standard documents confirm that resistors and capacitors contained asbestos including tape (Exhibit E). The National Bureau of Standards confirmed that it was standard for resistors to be wound with asbestos tape (Exhibit E). Westinghouse, for example and confirms that handling asbestos tape and wire releases dangerous levels of asbestos dust (Exhibit F). Ford sold the Aerospace business to Space Systems and asserts that by contract Space Systems is liable. Space Systems argues Ford is liable. The issue for this motion is that Dr. Frank reported that Kraus was exposed to electronic equipment on a regular and frequent basis. Since such products contained asbestos and were constantly and regularly opened releasing dust then 3 years of exposure to that electronic

equipment was substantial factor in the injury as a bystander. See *Rost v. Ford*, 151 A.3d 1032 (Pa 2016).

Dr. Frank will testify as permitted by Evidence Rule 703 from a hypothetical based on this evidence. Such meets plaintiff's burden to reach a jury. The Rules of Evidence 703 does not require experts to keep in their hands everything about every piece of equipment on the ship. The evidence is that Ford and Philco had numerous products on the ship containing asbestos which released dust he breathed. Dr. Frank will testify that since Kraus had exposure to asbestos from Ford/Philco's products on a regular and frequent basis for 3 years, that exposure was enough to cause the mesothelioma. This meets the burden he must meet to create a jury question. Further, as Dr. Frank notes, the asbestos defendants have deliberately and intentionally funded studies to rebut the generally recognized governmental and scientific views (Exhibit G). Their attempt to exclude here is part of the conspiracy and cover up.

PAUL, REICH & MYERS, P.C.

BY: Robert E. Paul

ROBERT E. PAUL

CERTIFICATE OF SERVICE

The undersigned certify that a true and correct copy of the within Plaintiff's answer to Space System/Loral's Motion to Exclude Dr. Frank has been filed electronically. This document is available for viewing and downloading from the ECF system and was served upon all counsel of record.

Robert E. Paul

Date: January 16, 2020

EXHIBIT A

IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF PENNSYLVANIA

ROBERT J. KRAUS and
MARGARET M. KRAUS, h/w,

Plaintiffs,

vs. No. 18-2119

ALCATEL-LUCENT, et al.,

Defendants.

VIDEOTAPED DEPOSITION OF ROGER GOSSETT

Suffolk, Virginia

Tuesday, August 20, 2019

MAGNA LEGAL SERVICES
(866) 624-6221
www.MagnaLS.com

REPORTED BY: DEBRA-LYNN BAKER, RPR, CSR

and answered.
BY MR. PAUL:
Q You can answer.
A Well, circuit boards are made in some of the equipment to plug in and, you know, circuit boards are made of fiberglass, to my knowledge, with the components mounted on them and then some sort of a clear plastic, plastic used in the generic sense, some kind of a sealer to prevent them from getting wet, getting dirty.
Q Do you recall any particular pieces of equipment that had circuit boards?
A Oh, yes.
Q Okay. Go ahead.
A Yeah. The cryptographic equipment, especially, had many circuit boards in it. That's the KWR-26 and the -- KWR-37, the KW-26, KW-7s, they were all pretty much modernized up to where they had 90 percent circuit boards.
Q Okay. And did you have -- where were these -- you did maintenance on these products?
A Yes.
Q Okay. And what part of the ship was that done in?
A Well, if you maintain a circuit

board, you pulled it out of the equipment, brought it down to the shop and troubleshot it right there in the --
Q Okay.
A -- in the shop.
Q Okay. When you opened up the equipment, what did you have to do to the equipment? And, again --
DEFENSE COUNSEL: Object to form, as overbroad.
BY MR. PAUL:
Q Again, we're -- we're talking about either the SRR-13 or the SRR-11 or the 390A or the URR --
DEFENSE COUNSEL: Same objection.
THE WITNESS: Yeah. Well, you know, depending on how the thing is made, it's -- once you get the equipment open to where you can get at the insides, there's a couple of screws or many screws that you have to take loose to get the module or the circuit board out.
BY MR. PAUL:
Q Okay.
A Pull it out, take it to the shop and fix it.

Q Did you ever have to use a vacuum cleaner?
A Yes.
Q Tell me about that. Why would you use a vacuum cleaner?
A Probably once a month, every couple of months you'd open the equipment up, vacuum it out, because dust collected in there, and it was part of our -- let me see. The name of the system was POMSEE. I don't, exactly, know what that stands for, but it was a preventative maintenance shipboard electronic where you cleaned the place out and made sure that everything was pretty and put it back together so that the dust did not accumulate.
Q Now, when you say once a month, you're talking about -- are you talking about once a month in the shop or once a month for each piece of equipment?
A Once a month --
DEFENSE COUNSEL: Objection; misstates his testimony.
THE WITNESS: Once a month for each piece of equipment. You know, you had a regular schedule --

BY MR. PAUL:
Q Okay.
A -- that -- you know, and -- and you had a little book, you had to sign it saying, yeah, yeah, we did it.
And you open it up, clean it out, clean the air filters, if so --
Q Okay.
A You know, if it had an air filter in it, and basically make sure it was lubricated and cleaned, put it back together. As long as it was working, leave it.
DEFENSE COUNSEL: Move to strike nonresponsive portions.
BY MR. PAUL:
Q During the time you were on the Cambria, how many pieces of equipment were maintained or repaired using the vacuum cleaner system that you have described in the shop itself?
DEFENSE COUNSEL: Object to form, calls for speculation, misstates the witness's testimony.
DEFENSE COUNSEL: Lacks time and scope.

DEFENSE COUNSEL: Objection to form, asked and answered.
BY MR. PAUL:
Q If you're able to.
A Specifically Belden Wire, I can't say any number of times. All I know is anytime we used wire I normally, you know, got it off of a roll. Most of the time, the roll said Belden Wire.
Q Okay.
A Now, whether I actually used Belden wire or Joe Smith wire, I can't say for sure.
Q Okay.
A Okay?
Q Are you able to say that you recall seeing Mr. Kraus near Belden wire --
DEFENSE COUNSEL: Objection; calls for speculation.
BY MR. PAUL:
Q -- if you're able to?
A Yes. In -- in the case of -- in the shop --
Q Right.
A -- the repair shop, we had, I would imagine, six or eight rolls of wire hanging off

the -- the workbench, and anytime we're working on anything and he's in the shop, he's right there. He's closer to the wire than you and I are right now.
Q Okay. And that's about --
A Yeah, 6 feet.
Q -- 4 feet, 5, 6 feet?
A Yeah, it's 4 feet. 3, 4 feet, yeah.
Q Okay. All right. What's the next company you checked off?
DEFENSE COUNSEL: Can I have a running objection to improper refreshing of recollection?
MR. PAUL: Okay. Sure.
Q Go ahead.
A The next company is Ford Motor Company.
Q Well, obviously we all know who Ford Motor Company is. What do you associate with Ford on the ship, if anything?
A Yeah, that -- I believe, but I'm not sure, they had something to do in the manufacture or something of the shipboard transmitter, but I don't remember exactly what.
Q You said the shipboard transmitter.

A Yeah. Well, the --
Q Which specific --
A -- the SRTs or --
Q -- or all of them?
A -- WRTs or -- one or -- or more. I don't -- I'm not sure.
Q Okay.
A I can't specifically say Ford Motor Company on the SRT, for example.
Q Okay.
DEFENSE COUNSEL: Motion to strike nonresponsive portions, speculation.
BY MR. PAUL:
Q Do you recall working on these Ford shipboard transmitters near Kraus?
DEFENSE COUNSEL: Assumes facts not in evidence, misstates testimony.
THE WITNESS: Okay. I recall working on the transmitters. Like I said --
BY MR. PAUL:
Q Right.
A -- I don't know for sure whether --
Q Sure, sure.
A -- it was labeled Ford or what, but I do remember --

Q Right.
A -- seeing Ford while I --
Q Okay.
A -- was aboard the Cambria.
Q Okay. Got it. Okay. Any -- any of the other defendants that you -- companies that you checked off, let's talk about those.
A General Dynamics, a manufacturer of the R-1051, WRC-1.
Q And we have talked about General Dy- --
A Yeah.
Q -- what you know about General Dynamics already.
A Yes.
Q Okay. Go ahead.
A Okay. Raytheon.
Q Okay.
DEFENSE COUNSEL: Let me interpose an objection. There's no question.
Is there a question, Bob?
MR. PAUL: Yeah. The question was what other ones does he remember and why.
DEFENSE COUNSEL: Okay. Then I object. First of all, it's inappropriate direct,

EXHIBIT B

IN THE COURT OF COMMON PLEAS

PHILADELPHIA COUNTY, PENNSYLVANIA

- - -

ROBERT J. KRAUS and MARGARET M. KRAUS, h/w	:	APRIL TERM, 2018
v.	:	
ALCATEL-LUCENT, et al.	:	NO. 3448

- - -

November 27, 2018

- - -

Videotape trial of ROBERT KRAUS, taken pursuant to notice, was held at the offices of Magna Legal Services, 1635 Market Street, Philadelphia, Pennsylvania, commencing at 9:40 a.m., on the above date, before Melissa Broderick, a Professional Court Reporter and Notary Public for the Commonwealth of Pennsylvania.

- - -

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maintaining and repairing all the electronic equipment.

And so I was responsible for making sure that all of the regulations -- and the Navy has a lot of regulations on when and where and what happens to every piece of that equipment. As a matter of fact, at one point in time, I had to sign for every piece of equipment, okay.

And so there were periodic maintenances that were required for different -- it varied depending on the piece of equipment. And we had a lot of other types of equipment, too, besides radios, but I won't go into that for this second.

But each piece of equipment had its own special card, okay. And it kept track of -- and other documents that went along with that -- kept track every time that one of those pieces of equipment came in, when it was maintained, when it was due for another

regular maintenance.

And we made changes to the equipment periodically, if it was improved or updated, and we would do some type of an alteration. A lot of these things were called ship alts.

And so I was just there for that purpose, to make sure that -- that position was to monitor, make sure that all of these things were done. If there was a particular issue with a particular piece of equipment, I had to know about it. I had to do something about it.

We've had situations where -- we had 24 landing craft on board that ship to land 1200 Marines that we carried. And the radios we were using on those boats, when we put the Marines in the water on our boats, they'd typically go out, and they would circle until they were all in this formation. They had to be able to communicate with the ship. They had to be able to communicate with each other. And they were still using

World War II radios that they were constantly breaking down.

So that was one of the things we had to find a resolution for, that is, me and -- I had the chief petty officer. That's equivalent to a sergeant in the Army, if you're not used to Navy lingo. And, eventually, to a master chief petty officer, as my ET crew grew from 12 to some higher number, 15 or so.

So it was an administrative job that doesn't sound very sexy, but it had an awful lot of problems that we had to work out.

Q. Well, you've mentioned -- used a couple of terms, and I wanted to ask you about those. You used the term "periodic maintenance" a minute ago.

A. Uh-huh.

Q. What is periodic maintenance? What happens in a periodic maintenance?

A. Typical piece of equipment -- most of the equipment on -- the

electronic equipment was rack mounted.

Q. What does that mean?

A. And that means there were literally these racks -- these structures that are like a framework. And there -- a lot of them are in the radio -- I say radio rooms. We had about -- I think, up to five radio rooms on the ship, because we were the flagship, so we carried the flag officer. He had all of his own -- duplicated everything we had except for the radars.

So maintenance, we would bring the piece of equipment in. We'd take it out of the rack. So now, where you could originally see the front panel, but you couldn't see the rest of the particular electronic equipment, when you took it out, you could see all of that because it was cabinets that enclosed it were still sitting back in the radio room.

We'd bring it down to the ET shop. And the first thing they would do

is they would clean it, okay.
Q. When they cleaned it, what did they do?
A. There were two different ways they typically cleaned it. One, they used a vacuum, and would vacuum out every part of the radio they could get to.
And the second was -- well, they used some chemicals periodically, if there was corrosion, or if there were problems with any equipment making proper contact with switches, for example, that were in there. We would -- so that was it.
DEFENSE COUNSEL: Belated objection. Overbroad as to equipment and time.
BY MR. PAUL:
Q. Why did the radios and these other pieces of equipment have to be vacuumed?
A. Easiest way to say it is they got dirty. It's like anything else

in your house, if you let it sit there for a long time -- and they were -- and they were hot, typically.
DEFENSE COUNSEL: Same objection.
THE WITNESS: Most of the radios had electronic tubes. Some had electronic tubes and transistors, a combination. And if you've ever looked in anything -- any piece of equipment, like your TV, for example, at home, it's going to get very dusty inside.
And so that's basically what they were doing, vacuuming whatever dust was in there.
BY MR. PAUL:
Q. What do you recall -- do you recall any components of these radios?
DEFENSE COUNSEL: Objection. Overbroad as to equipment and to time.
MR. PAUL: You can answer

the question.
THE WITNESS: Could you repeat the question?
MR. PAUL: Yeah. Have it read back.
- - -
(The court reporter read the pertinent part of the record.)
- - -
DEFENSE COUNSEL: Also compound.
THE WITNESS: I'm not sure what you mean by components, but, for example, there were circuit boards.
BY MR. PAUL:
Q. Circuit boards?
A. If that's what you're talking about, yeah, circuit boards.
Q. Okay.
A. The tubes themselves. They were all components. So if a tube went bad, you could pull it and replace it.
Q. Okay. Circuit boards, you

have to pull circuit boards yourself?
A. We would --
DEFENSE COUNSEL: Same objections.
THE WITNESS: There were two ways -- two kinds of ways to take care of circuit boards problems. One, you could find out if there was component that was bad, for example. Well, the tube I just mentioned. But they both have circuit boards.
But the transistor, you could detect a bad transistor and replace that. Sometimes, if you couldn't find the problem in the circuit board, then you replace it, yeah.
DEFENSE COUNSEL: Move to strike nonresponsive portions.
BY MR. PAUL:
Q. Was there any kind of cloth or pad inside the radios?
DEFENSE COUNSEL: Objection;

EXHIBIT C

NAVSHIPS 92383.41

APPROVED MANUSCRIPT

MAINTENANCE CHECK-OFF BOOK

for

RADIO SET AN/GRC-27

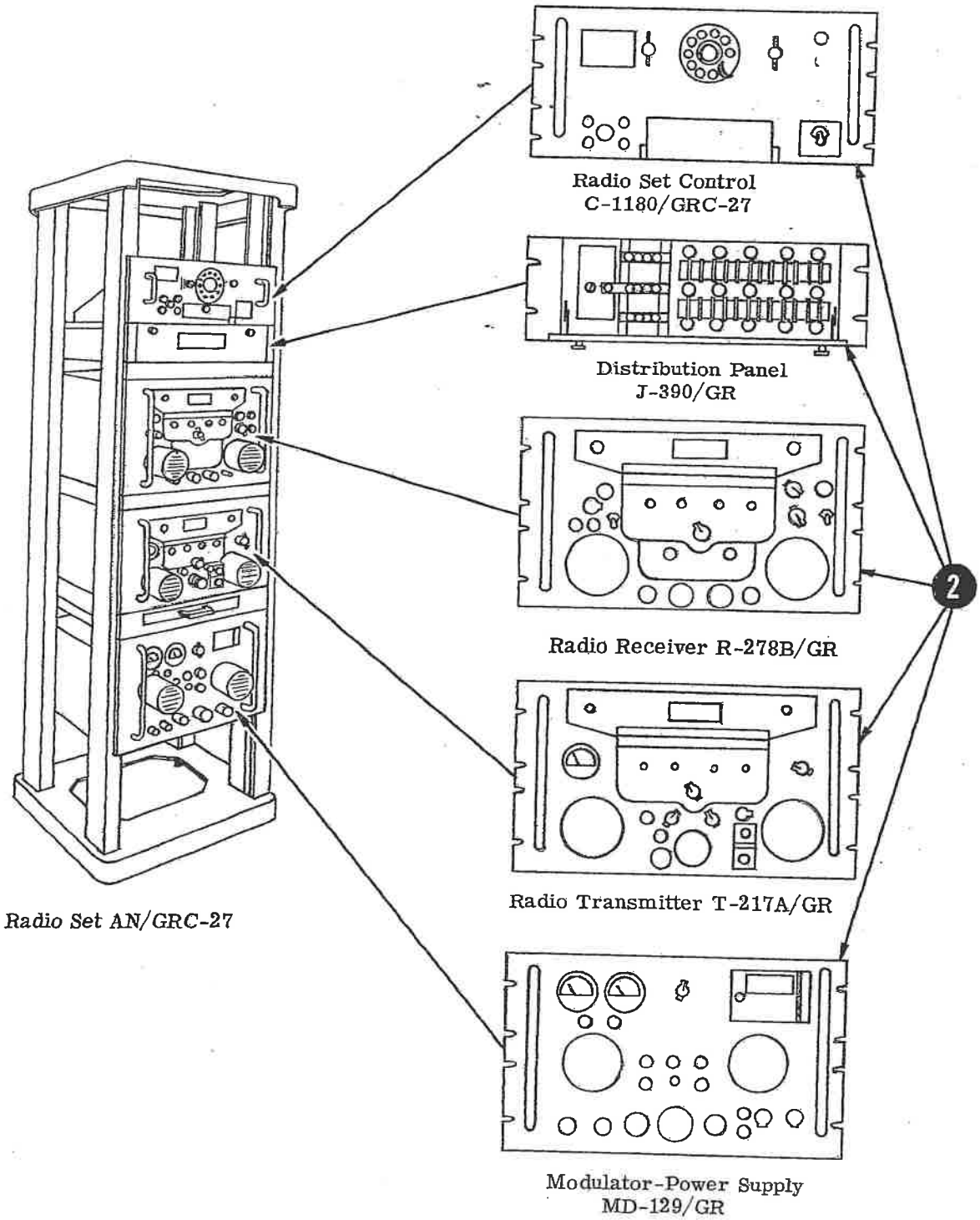
SERIAL ———

PHILCO CORPORATION
PHILADELPHIA, PENNSYLVANIA

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS

Contract: NObsr 63504 *Approved by BuShips: 11 January 1955*

Step 2



Radio Set AN/GRC-27

Operating Conditions and Control Settings:

Throw EMERGENCY switch at Radio Set Control C-1180/GRC-27 to OFF. Disconnect cables and remove components from rack and from cases.

STEP NO.	STEP ACTION REQUIRED	PRELIMINARY ACTION	READ INDICATION ON	PERF. STD.
2	Clean inside and outside of Radio Set AN/GRC-27. Check general condition of parts.	With dry-air blower, clean out any dust, dirt, or foreign matter from inside and outside of chassis. Make sure that the air screens at the driver, power amplifier, between the tuners, on the covers of the driver section, etc, are absolutely clean. Any obstruction of air flow may damage the transmitter. Examine tubes for proper seating, cracked bases, overheated transformers, overheated resistors and capacitors, and leakage of potting compounds and oil filters. CAUTION Do not disturb any wiring within the chassis. Some circuits within this equipment operate at high-frequencies, the wiring serving as part of the tuned circuits. Disturbing the wiring may detune these circuits and cause inefficient operation.		

Time Schedule: Record and initial.

Week	Step	Jan. 19__	Feb. 19__	Mar. 19__	Apr. 19__	May 19__	June 19__	July 19__	Aug. 19__	Sept. 19__	Oct. 19__	Nov. 19__	Dec. 19__
1	2												
2													
3													
4													
5													
Initial													

NAVSHIPS 92755.41

APPROVED MANUSCRIPT

MAINTENANCE CHECK-OFF BOOK

for

RADIO SETS AN/SRC-10,-10X,-10Y,-11,-11X,-11Y,-12,-12X,-12Y AND AN/URC-16,-16X,-16Y,-17,-17X,-17Y,-18,-18X,-18Y.

SERIAL ———

PREPARED BY
PHILCO CORPORATION
PHILADELPHIA, PENNSYLVANIA

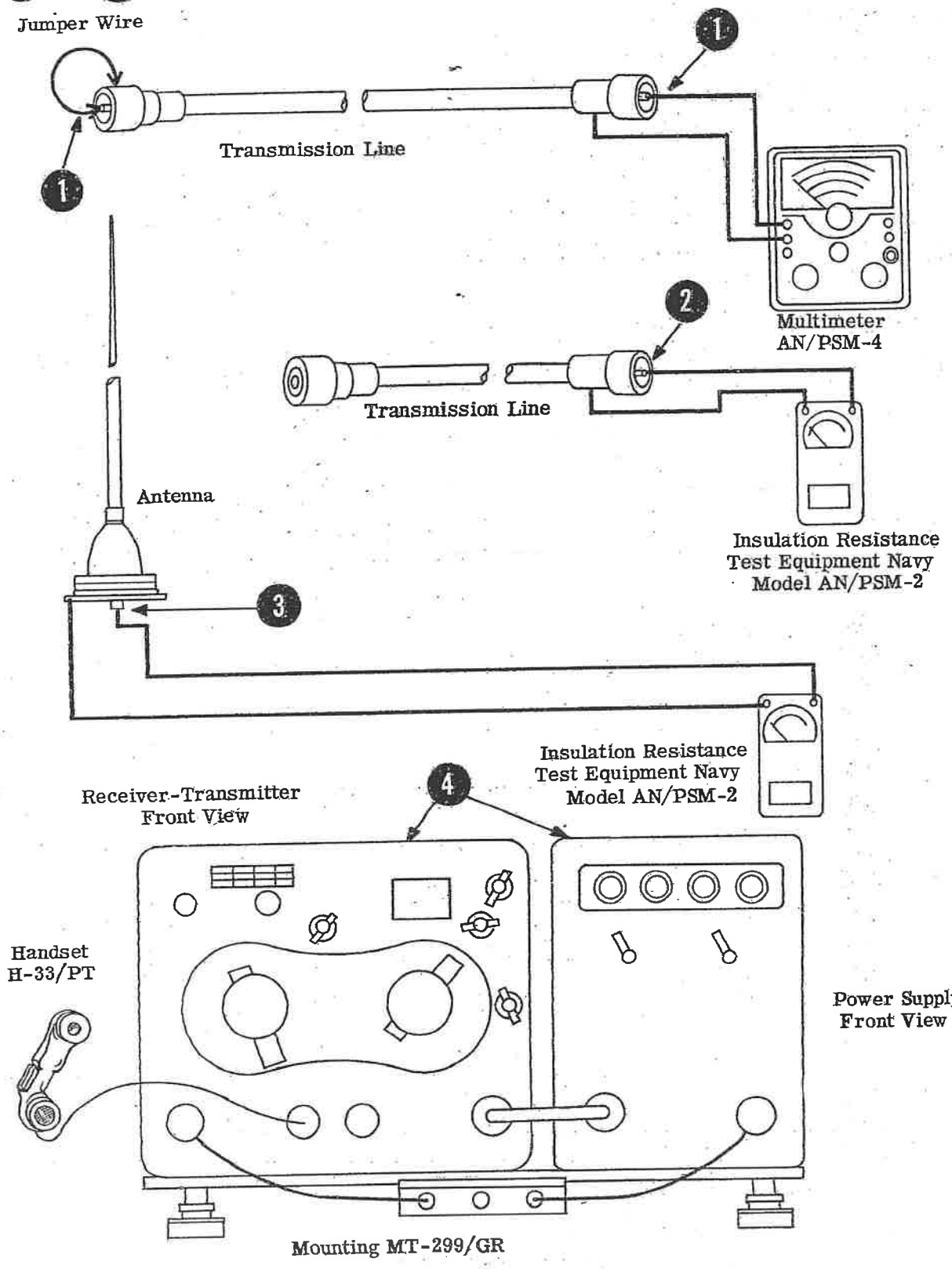
BUREAU OF SHIPS NAVY DEPARTMENT

Contract: NObsr 64183 *Approved by BuShips: 4 May 1956*

Monthly

Steps 1 thru 4

AN/SRC-10, -11, -12 Series
AN/URC-16, -17, -18 Series



ORIGINAL

Monthly

AN/VRC-8, -9, -10

Steps 1 thru 4

Operating Conditions and Control Settings:

Primary power, antenna, and transmission line disconnected

Test Equipment Required:

Multimeter AN/PSM-4
Insulation Resistance Test Equipment Navy Model AN/PSM-2
Signal Generator AN/URM-25
Multimeter AN/USM-34

STEP NO.	STEP ACTION REQUIRED	PRELIMINARY ACTION	READ INDICATION ON	PERF. STD.
1	Record transmission-line resistance.	Connect equipment as shown on opposite page. Set Multimeter AN/PSM-4 function switch: R x 1. See page ii.	Multimeter AN/PSM-4	_____ohm (See page ii.)
2	Record transmission-line insulation resistance.	Connect equipment as shown on opposite page.	Insulation Resistance Test Equipment Navy Model AN/PSM-2	_____meg (50 or over)
3	Record antenna insulation resistance.	Connect equipment as shown on opposite page.	Insulation Resistance Test Equipment Model AN/PSM-2	_____meg (50 or over)
4 **	Clean inside and outside of Radio Set.	Remove all dust, dirt, and foreign matter from the equipment. Remove any rust and apply rust preventative or repaint the area in accordance with existing Navy procedures.		

Time Schedule: Record and initial.

Approx Time Reqd for Monthly Steps — 1 hr

Month	Jan. 19__	Feb. 19__	Mar. 19__	Apr. 19__	May 19__	June 19__	July 19__	Aug. 19__	Sept. 19__	Oct. 19__	Nov. 19__	Dec. 19__
Step 1												
Step 2												
Step 3												
Step 4												
Initial												

ORIGINAL

NAVSHIPS 91875.41

APPROVED MANUSCRIPT

MAINTENANCE CHECK-OFF BOOK

for

RADIO RECEIVING SETS AN/SRR-11, AN/SRR-12, AN/SRR-13

MODEL ———

SERIAL ———

PHILCO CORPORATION
PHILADELPHIA, PENNSYLVANIA

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS

Contract: NObsr 64183

Approved by BuShips: 4 May 1955

Operating Conditions and Control Settings:

AN/SRR-11, -12, or -13 de-energized

STEP NO.	STEP ACTION REQUIRED	PROCEDURE
4	Overhaul Radio Receiving Set AN/SRR-11, -12, or -13 as directed.	Inspect front and rear panel of receiver for accumulation of dirt. If dirty, clean, with non-linting cloth moistened with Dry Cleaning Solvent (Federal Spec P-S-661, Type II); SNSNG51-S-4718-1D 140F then dry, using non-linting cloth. Sandpaper all rusty areas; clean, and repiant with matching color. Check all loose assembly screws and four mounting bolts; tighten, if necessary; replace, if missing. Inspect cable cords and plugs for wear and broken parts. Contact surface of plugs may be cleaned with crocus cloth. Examine pilot covers for cracks or breaks. Dust light jewels with a clean cloth. Glass windows of projection and logging dials, and meters should be polished with a clean cloth. WARNING Before proceeding further with this step, it is imperative that the ship's primary a-c supply be disconnected from the AN/SRR-11,-12, or -13. Pull receiver chassis out of cabinet to the service position which will give access to bottom of receiver. Using solvent-moistened cloth, clean all accessible interior surfaces, taking care that lubricated points are avoided. Remove the two cartridge-type fuses, inspect for correct ampere rating, and test for continuity. Procure correctly rated fuses, if needed. Clean mirror with a soap solution or alcohol and wipe the mirror softly. Lens-cleaning tissues are not recommended. Visually inspect the mechanical action of all controls. If sticking occurs, check that all mountings and connections are tight. All shafts should rotate freely. All switches must be inspected for damage due to arcing. Approved burnishing tools must be used to burnish contacts when necessary.
5	Make electron tube inspection.	Checking tubes in this equipment as a periodic maintenance procedure is not recommended, because of the placement of the subminiature electron tubes. However, the two high-voltage rectifier tubes and ballast resistor used in the power supply can be checked. WARNING Avoid touching tubes immediately after shutdown. Severe burns may result from contact with the hot glass envelopes or metal shields of the tubes. Inspect these tubes for loose envelopes, and also, inspect for firmness of seating in sockets by pressing tubes inward, taking care not to move them from side to side.

Time Schedule: Check-off (✓) and initial.

Month	Jan. 19__	Feb. 19__	Mar. 19__	Apr. 19__	May 19__	June 19__	July 19__	Aug. 19__	Sept. 19__	Oct. 19__	Nov. 19__	Dec. 19__
Step 1 (4)												
Step 2 (5)												
Initial												

AN/SRR-11, -12, or -13

Steps 1 thru 3

Operating Conditions and Control Settings:

Primary power disconnected from AN/SRR-11, -12, or -13

Test Equipment Required:

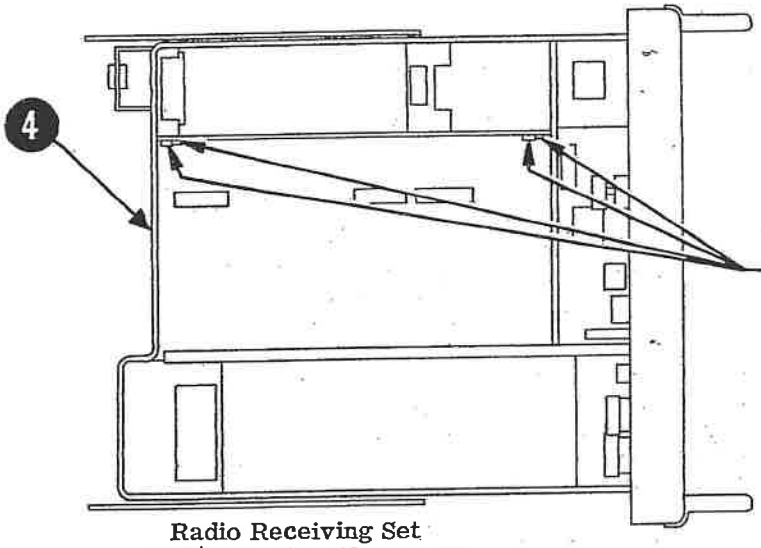
None

STEP NO.	STEP ACTION REQUIRED	PROCEDURE
1	Inspect and clean all moving parts in Receiving Set AN/SRR-11, -12, or -13.	Pull receiver chassis out of cabinet to the service position which will give access to bottom of receiver. Remove dust from chassis and assemblies, using small blower. Remove all caked and dirty lubricant from all moving parts with Dry Cleaning Solvent 140-F (5 gal drum, stock number G51-S-9718-10).
2	Lubricate chassis positioning mechanism.	Using a camel's-hair brush, apply thin film of grease (MIL-G-3278) sparingly to handle pivot, gear teeth, and chassis track. Wipe off excess. Apply two drops of oil (14-0-20-ORD) to push-rod pin, idler bearing, pull-in latch shaft and bearing, latch-on fulcrum, and slide release on fulcrum. Wipe off excess.
3	Lubricate moving parts from top of chassis.	Using a camel's-hair brush, apply thin film of grease (MIL-G-3278) sparingly to bevel gears for antenna trimmer (on AN/SRR-11 only), miter gear and detent on RECEPTION switch, and guide buttons. Wipe off excess. Apply two drops of oil (14-0-20-ORD) to bearing for antenna trimmer (on AN/SRR-11 only), and to tilting fulcrum. Wipe off excess.

Time Schedule: Check-off (✓) and initial. Approx Time Reqd to Complete Semiannual Steps — 1-1/2 hr

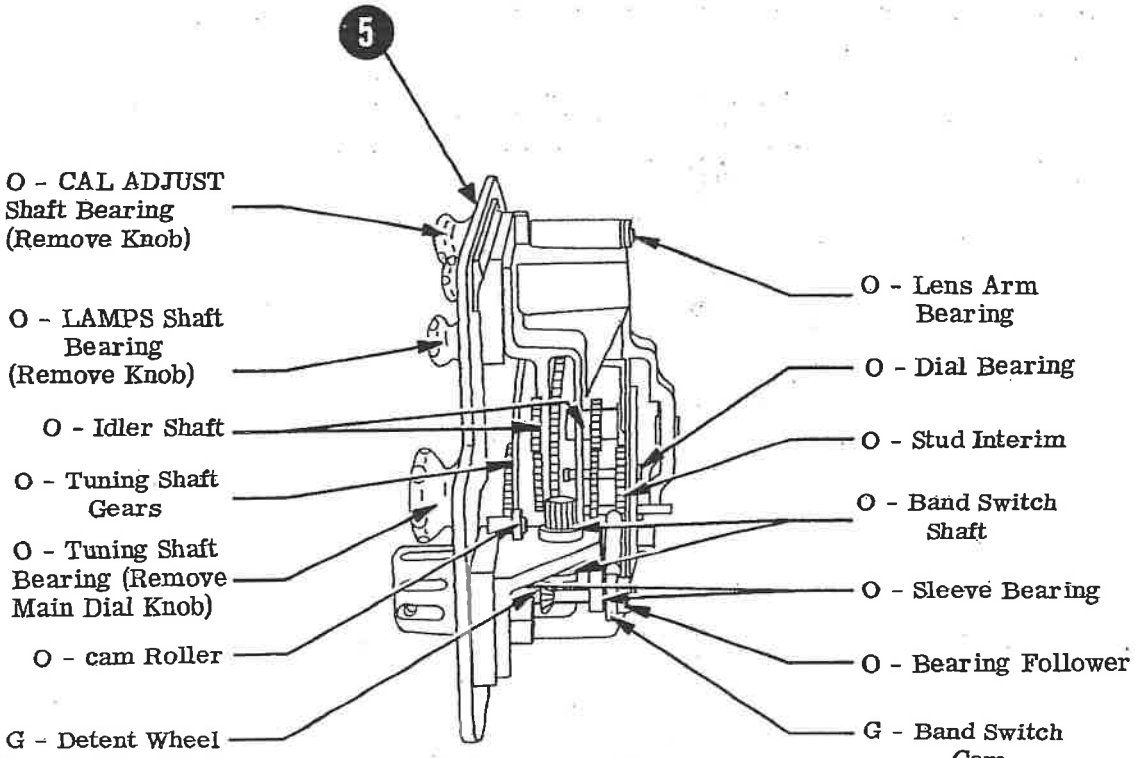
Semi-annual	1st Half 19____	2nd Half 19 ____
Step 1		
Step 2		
Step 3		
Initial		

Steps 4 and 5



Radio Receiving Set AN/SRR-11, -12, or -13, Bottom View

G - Grease MIL-3278
O - Oil 14-0-20(ORD)



Radio Receiving Set AN/SRR-11, -12, or -13, Tuning Dial Assembly

NAVSHIPS 92121.41

APPROVED MANUSCRIPT

MAINTENANCE CHECK-OFF BOOK

for

RADIO TRANSMITTING SETS AN/SRT-14, AN/SRT-15 AND AN/SRT-16

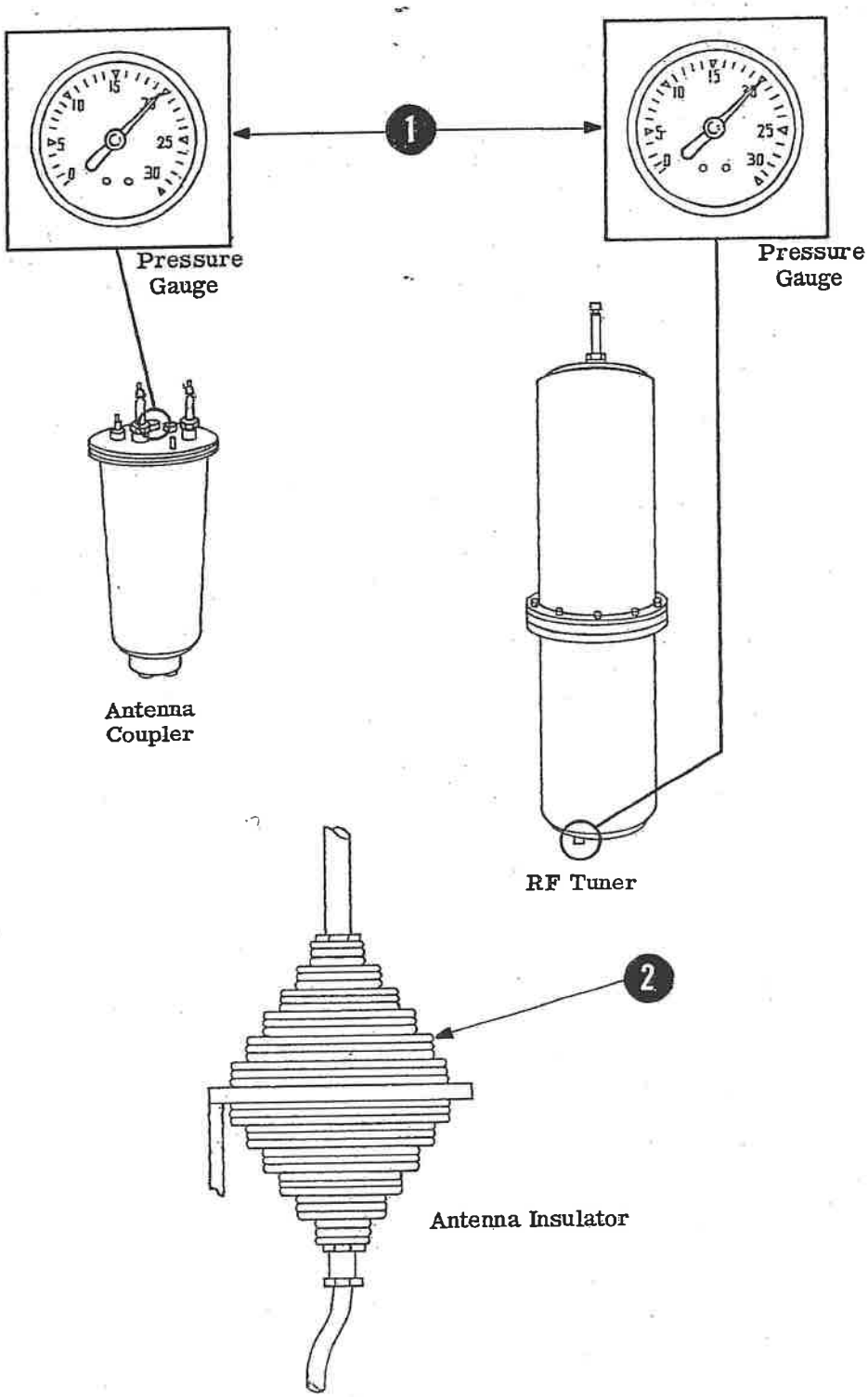
SERIAL ———

PREPARED BY
PHILCO CORPORATION
PHILADELPHIA, PENNSYLVANIA

BUREAU OF SHIPS NAVY DEPARTMENT

Contract: NObsr 64183 *Approved by BuShips: 19 June 1956*

Steps 1 and 2



AN/SRT-14, -15, -16

Steps 1 and 2

Operating Conditions and Control Settings:

Transmitter primary power turned off.

Test Equipment Required:

Multimeter AN/PSM-4

STEP NO.	STEP ACTION REQUIRED	PRELIMINARY ACTION	READ INDICATION ON	PERF. STD.
1	Record RF Tuner and Antenna Coupler gas pressure.	Check RF Tuner and Antenna Coupler gas pressure. If pressure is less than 20 psi, refill to 20 psi, using Pressurization Kit MK-260/U.	RF Tuner and Antenna Coupler pressure gauges	
2 **	Clean anntenna insulator.	Clean the antenna insulator with a dry cloth.		

Time Schedule: Record and initial.

Approx Time Reqd for Weekly Steps — 1 hr

Week	Step	Jan. 19_	Feb. 19_	Mar. 19_	Apr. 19_	May 19_	June 19_	July 19_	Aug. 19_	Sept. 19_	Oct. 19_	Nov. 19_	Dec. 19_
1	1												
	2												
2	1												
	2												
3	1												
	2												
4	1												
	2												
5	1												
	2												
Initial													

AN/SRT-14, -15, -16

Steps 5 thru 9

Operating Conditions and Control Settings:

Transmitter primary power turned off.

STEP NO.	STEP ACTION REQUIRED	PRELIMINARY ACTION
5	Lubricate transmitter cabinet frame.	Apply two drops of Oil, lubricating, MS-9030, to bearing surfaces of roller shafts of drawer support rollers. Apply one drop to each latch stud assembly.
6	Lubricate Radio Frequency Amplifier.	Apply one drop of Oil, lubricating, MS-9030, to each of the points indicated on opposite page.
7	Lubricate Radio Frequency Amplifier.	Distribute 1/4-inch diameter ball of Lubricant, ball and roller bearing, Spec 14-L-2C, over 2-inch length on sprocket side of chains, as indicated on opposite page.
8	Lubricate Radio Frequency Amplifier.	Distribute rice grain amount of Grease, aircraft and instrument, MIL-G-3278, on all points indicated on opposite page except the six racks and the two PA tuning chains. Apply a thin film on the racks and a 3/4-inch diameter ball of grease to the accessible portions of each chain.
9	Clean air filters.	Remove air filters from cabinet, and clean in Dry Cleaning Solvent (SNSN G51-S-4718-10); then dry and re-oil with Oil, lubricating, MIL-L-9000-B. Drain off excess oil and replace filters in cabinet.

Time Schedule: Initial.

Quarter	1st Quarter 19___	2nd Quarter 19___	3rd Quarter 19___	4th Quarter 19___
Step 5				
Step 6				
Step 7				
Step 8				
Step 9				
Initial				

EXHIBIT D

A Yeah.
Q -- what did you have to do to that wire?
And, again, I'm talking about the 390 for the moment. I'll get to some of the other stuff in a bit.
A Well, it's just a matter of determining, you know, you need a wire that's this long or that long, you cut it off, you strip the ends off of the insulation off the wire to expose the conductor and solder it back into place --
Q Okay.
A -- whether it's, you know, 2 inches long or a foot long.
Q What happened when you -- when you cut the wire, as you describe it? Did you see anything happen, or did you see anything in the air?
DEFENSE COUNSEL: Objection; form.
BY MR. PAUL:
Q You can answer the question.
A No. Well, when you cut the wire, the insulation -- you have special cutters for the wire which, you know, will cut the insulation but

not the wire.
Q Yeah.
A And once you cut it, the insulation goes flying into the trash can or on the floor.
Q Did it ever fly in your face?
DEFENSE COUNSEL: Objection to form, leading.
THE WITNESS: No.
BY MR. PAUL:
Q Okay.
A You've got to be careful, you know, you don't do things like that.
Q Right. Were there any other pieces or components of the R-390 that you recall?
A Mechanical components.
Q Well, tell us about electronic.
A Yeah.
Q Okay. What's a resistor?
A A resistor is a piece of electrical equipment that's made to -- to impede the flow of electronics, and how much it impedes it depends on how it's made. You can get them that are very low resistance or very high resistance --
Q Okay.
A -- and --

Q Do you know how they're made?
A Basically, yeah. A bunch of -- first of all, the engineers determine what resistance they need. Okay? They're made in certain steps. The compounds that -- the resistive conductive compounds are chosen to provide this plus-or-minus resistance.
Q Okay.
A And then they're incorporated into a package with other stuff to keep them -- what can I say? To keep it together --
Q Okay.
A -- okay, with two wires sticking out the end.
That -- that's strictly the -- the manufacturing process. Okay? That has nothing to do with my end where I --
Q Sure.
A -- replace the resistors.
But that's -- yeah, that's --
Q Do you know any --
A -- that's basically how I -- how I know a resistor is made.
DEFENSE COUNSEL: Move to strike, lacks foundation, basis of foundation,

speculation.
BY MR. PAUL:
Q Do you have any knowledge about what the compounds were made of?
A No, I haven't the slightest.
Q Now, we're talking about the 390 for the moment.
A Okay.
Q Was there a difference in resistor -- well, were resistors used in lots of other -- in other equipment?
A Yes.
Q Okay. What other pieces of equipment were the resistors used in that you recall?
DEFENSE COUNSEL: Objection. Again --
THE WITNESS: Every piece of electronic equipment on the ship has resistors in it.
BY MR. PAUL:
Q Okay.
A Whether it has -- you know, the number is -- depends on the complexity of the equipment. Some of the -- the transmitters had hundreds of resistors.

EXHIBIT E

ENCLOSURE I

ENCLOSURE I

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, D.C. 20350

IN REPLY REFER TO
Ser 4542/318054
5 Jan 1979

Mr. Robert F. Hughes
Assistant Director
U. S. General Accounting Office
Human Resources Division
Washington, D. C. 20548

Dear Mr. Hughes,

This is in response to your letter of October 5th in which you requested information on the extent to which asbestos is being used in the Navy's shipbuilding and ship repairing operations. This response reflects our understanding of the scope/detail of your request as amplified by Mr. Joseph Daigle of your staff during a meeting in late October.

In response to questions 1, 2 and 4, attachment #1 provides a listing of U. S. Navy ships (class, name and hull number) which were delivered since 1973 or are under construction and also provides information regarding the status of thermal insulation. Each ship has several types of asbestos containing materials installed; however, thermal insulation for machinery, equipment and piping systems has been the major application of asbestos.

Even though the use of asbestos as thermal insulation has been eliminated, there remain a few shipboard applications where technically acceptable substitute asbestos-free materials have not yet been identified. Therefore, all ships presently in service contain some quantity of asbestos.

Asbestos fibers are incorporated in the plastic-like body of certain electrical resistors found in home, TV and stereo equipment and in Navy electronic equipment. Asbestos is used in home and office floor tiling and on Navy ship decks. Asbestos is used on electric cabling found in many commercial ovens, home hot water heaters and in Navy galley ranges. Piping system gaskets and packing used throughout thousands of American industries and homes and in Navy shipboard piping systems contain asbestos. Asbestos is used in automotive brakes and clutches and in Navy ship equipment brakes and clutches. The list is nearly endless. There are so many common uses of asbestos that it is nearly impossible to build a Navy ship free of the mineral.

EXHIBIT
P6

PENGAD 800-631-6989

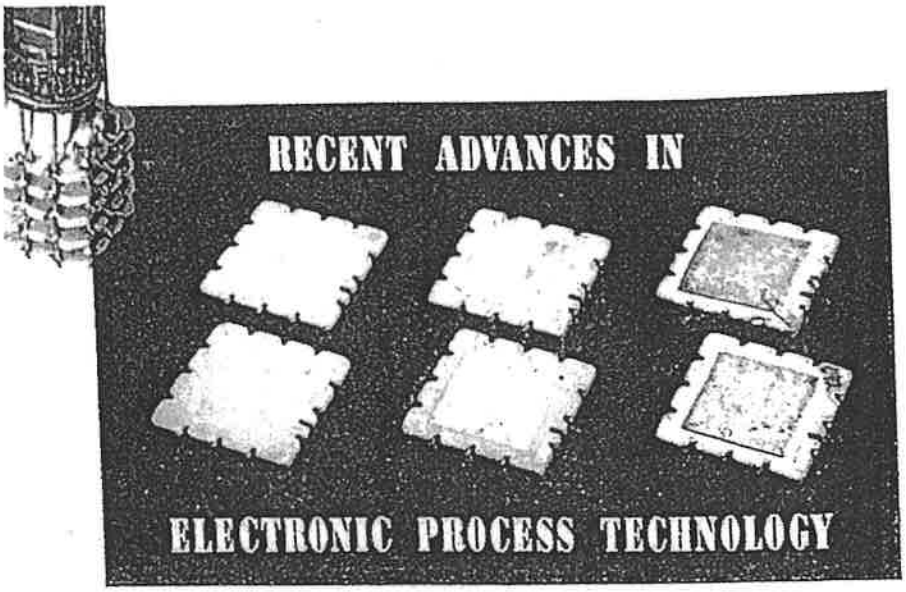
ENCLOSURE I

d. Despite the enormous cost, replacement of asbestos thermal insulation in ships will not eliminate asbestos exposure of civilian and military Navy personnel. According to the National Institute for Occupational Safety and Health, asbestos dust is everywhere. Low but easily measurable levels of airborne asbestos dust are found in the air of cities throughout the country, much of it generated by automotive brake and clutch linings. Asbestos is used in so many products that most of the U. S. populace unknowingly encounters it daily.

I hope this information satisfactorily answers your inquiry regarding the extent to which asbestos is being used in the Navy's shipbuilding and ship repairing operation.

Sincerely,

J. J. Bu[illegible]
Vice Admiral, U.S. Navy
Deputy Chief of Naval
Operations (Logistics)



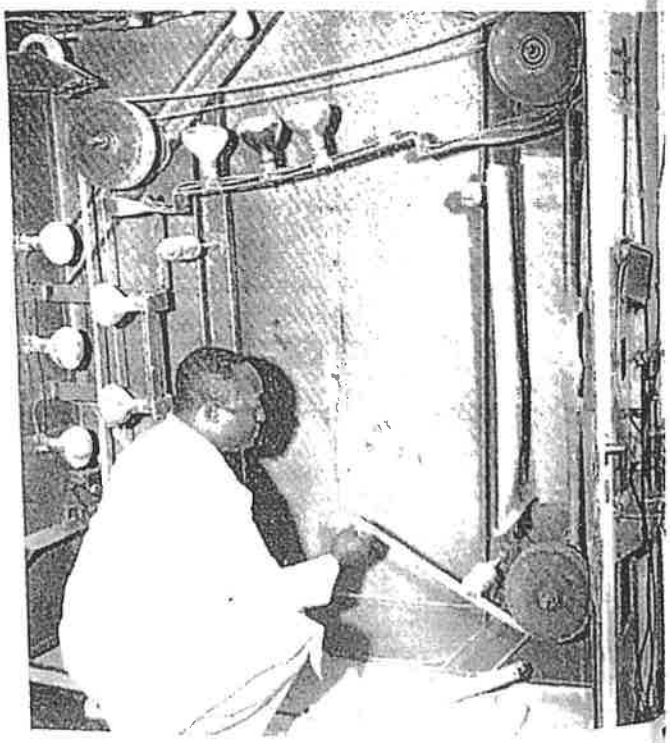
MDE–MPE tape capacitors in stages of production. Wafers at left are cured steatite blanks of same general type used in MDE–MPE system. Silver pattern that forms one electrode of capacitor has been applied to two wafers in the center. In wafers at right, adhesive dielectric-coated tape is cut into squares slightly larger than the silver contact and then pressed down onto the wafers. After curing, the capacitor is ready to be assembled into a module with other wafers such as that shown at top left.

SINCE the announcement of a new system for the mechanized production of electronics in 1953, the National Bureau of Standards has developed additional compatible components and techniques under the sponsorship of the Navy Bureau of Aeronautics. Recent advances achieved by NBS in electronic process technology include an adhesive tape capacitor, a "chip" resistor, and a method for applying pyrolytic carbon resistors. Developed by B. L. Davis of the Bureau's process technology laboratory, these components and techniques should do much to increase the versatility and applicability of electronic equipment manufactured by automatic production lines.

The development of systems for Modular Design of Electronics and Mechanized Production of Electronics (MDE–MPE), formerly code-named Project Tinkertoy, was begun by the Bureau with the cooperation of several industrial companies under the sponsorship of the Navy Bureau of Aeronautics as an industrial preparedness measure. The MDE–MPE system starts with raw or semiprocessed materials and automatically manufactures ceramic base wafers, dielectric elements for capacitors and adhesive tape resistors; prints conducting circuits and capacitors; and mounts resistors, capacitors and other component parts on standard, uniform steatite wafers. The wafers are stacked like building blocks to form modules that perform all the functions of one or more electronic stages. The pilot plant, operated by a commercial contractor, incorporates the principles of this system. The plant was designed to produce 1,000 finished and inspected modules per hour.

The Tape Capacitor

The self-adhesive tape capacitor is designed specifically for application to the ceramic wafer by MDE–MPE machine techniques. It is manufactured in much the same manner as the NBS adhesive-tape resistor.[1] A conducting tape, coated on one side with a dielectric, provides one element of the capacitor. The other element is a silver pattern printed and fired on the wafer. It is now possible to apply an adhesive-tape



In this chamber electrically conducting solution is sprayed on one side of tape, dried, and then sprayed on other side. When cured, dielectric formulation is sprayed on one side of tape. It is then ready to be used as one element of the capacitor. Spray unit can be seen at far right.

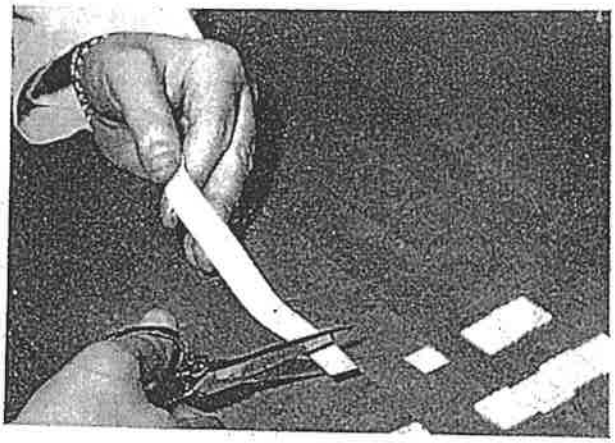
Application of adhesive tape capacitor to wafer. Although shown here as a manual operation for demonstration purposes, it is normally applied by machine.

resistor to one side of a wafer and an adhesive-tape capacitor to the other side.

The materials required for the manufacture of tape capacitors are a heat-resisting asbestos paper tape, silver flake, silicone resin, butyl cellosolve, a powdered high-K titanate body, *n*-hexane, and epoxide resin. The electrically-conducting formulation (a mixture of the silver flake, silicone resin, and solvent) is ground in a ball mill. The mixture is sprayed on a loop of tape 1¼ in. wide, allowed to dry thoroughly, and then sprayed on the other side. When cured, the metallized tape is conductive along each side and from one side to the other. After slitting along the center to form two ⅝-in tapes, it is ready for application to the dielectric film. A roll of tape 19 ft long will produce about 350 capacitors.

The dielectric formulation is composed of high-K titanate body that has been pulverized in a ball mill with *n*-hexane until the particle size is about 1 to 2 microns, after which the slurry is allowed to evaporate under a hood. The ground titanate body is mixed with epoxide resin and further ball-milled. This tacky dielectric mixture is then sprayed on the metallized base tape in various thicknesses determined by the number of passes the tape makes in front of the spray gun. Thicker applications, of course, make capacitors of lower value.

The silver pattern that forms one electrode of the capacitor is applied to the steatite wafer by means of a screen press. It is then dried and fired onto the ceramic. The adhesive dielectric-coated tape that forms the other electrode is cut into squares slightly larger than the silver contact and pressed down on it. A narrow conductive strip, similar to resistor tape but with a conductivity of approximately 0.02 ohm per half inch, is laid down between a contact on the edge of the wafer and the top side of the capacitor. The



complete assembly is then cured by placing it in a oven at room temperature, raising it to 225° C over period of one-half hour, and holding the temperatur at 225° C for 45 minutes.

Capacitors of higher values can be manufacture by applying a number of layers of tape, one on to of another, with appropriate connections to the edg of the wafer. Smaller capacitors can be made by reducing the area of the silver pattern printed on the wafer, or by increasing the thickness of the dielectric layer. For typical values, see table 1.

Second element of capacitor is a silver pattern printed on an MDE-MPE wafer. Elements may be printed on either or both sides, depending on requirements of finished circuit. An adhesive tape resistor can be applied to opposite side of wafer instead of a capacitor, if desired.

Shelf life tests indicate that the capacitance changes no more than 1 percent during the first month after manufacture, and that there is no change in the dissipation factor, which averages 0.7 percent at 1 kc. However, the capacitance does change somewhat with temperature, −3 percent from 25° to 85° C, and −15 percent from 25° to −55° C. In a load life test, a few capacitors shorted out, but otherwise only negligible changes occurred in capacitance and dissipation factor.

The "Chip" Resistor

The "chip" resistor is made by applying self-adhesive resistor tape to a small chip of ceramic material. This resistor is not for use in the regular quantity production of modules, but aids the electronic design engineer in studying new modular circuits which are still in the "breadboard" stage or in producing prototype equipments for evaluation. The chip is inserted into a circuit simply by soldering it to the appropriate connections on a standard wafer.

The precured resistor tape is manufactured automatically by the usual MDE–MPE techniques but is applied to a chip of cured steatite about 0.600 by 0.225 in. instead of the standard MDE–MPE wafer. A prototype machine developed in the NBS laboratories

of a highly accurate gas thermometer for this purpose requires painstaking and time-consuming precision, the work on the secondary thermometer is being pursued concurrently. Resistance thermometers constructed of the semiconducting elements, silicon and germanium, have proved to be extremely sensitive; in some cases the resistance changes more than 50 percent per degree. While satisfactory reproducibility still remains a problem, results of initial tests have been quite promising.

References

[1] New International Temperature Scale, NBS Technical News Bulletin **33**, 28 (1949).

[2] H. F. Stimson, The International Temperature Scale of 1948, J. Research NBS **42**, 211 (1949) RP1962.

[3] Robert J. Corruccini, Differences between the International Temperature Scales of 1948 and 1927, J. Research NBS **43**, 133 (1949) RP2014.

[4] H. F. Stimson, The measurement of some thermal properties of water, J. Washington Acad. Sci. **35**, 201 (1945).

[5] NBS Technical News Bulletin, No. 305, 71 (1942).

[6] J. B. Garrison and A. W. Lawson, Absolute noise thermometer for high temperatures and high pressures, Rev. Sci. Inst. **20**, 785 (1949).

[7] Robert J. Corruccini, Annealing of platinum for thermometry, J. Research NBS **47**, 94 (1951) RP2232.

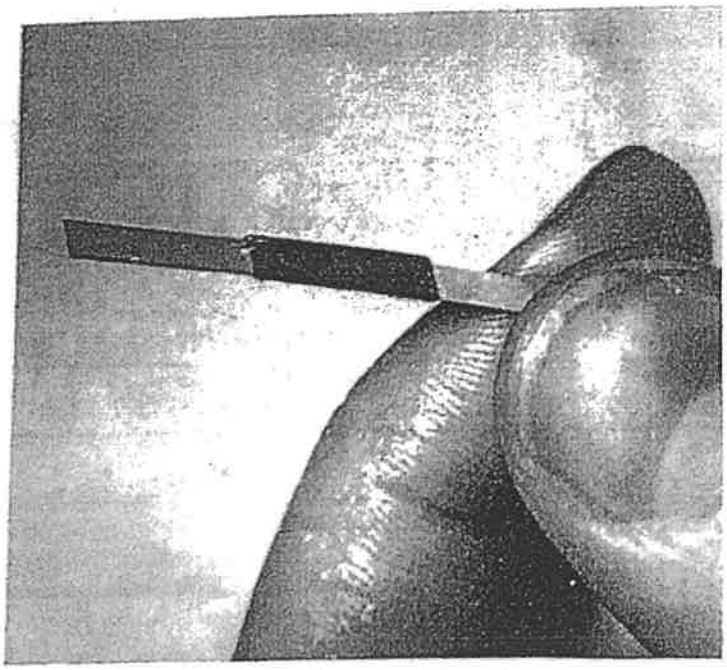
[8] Lawrence C. Liberatore and Raymond E. Wilson, Aging changes in clinical thermometers, J. Am. Ceramics Soc. (In press).

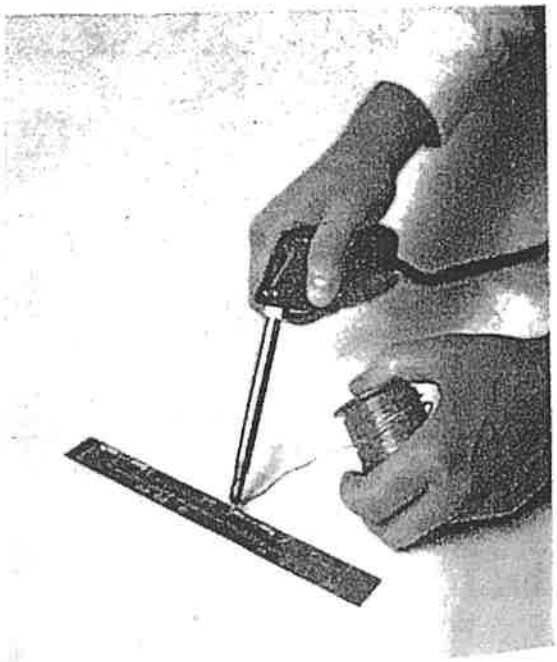
NBS Precured Tape Resistor

THE ADHESIVE-TAPE resistor developed by the Bureau has aroused wide interest since its announcement in 1951.[1] In the NBS tape-resistor system, designed primarily for electronic printed-circuit applications, small pieces of self-adhesive resistance-coated tape are simply pressed into place against metallic terminals at the proper points in the circuit. The resistor was developed as part of a program of miniaturization of airborne equipment sponsored by the Navy Bureau of Aeronautics. Despite its advantages, the method has been limited in some applications by the necessity for baking the supporting base material to cure the resistors after they have been pressed in place.

A new precured wire-lead version of the tape resistor, now being made at NBS, obviates the need for heat-curing after placement in the circuit. The new resistors are made by pressing uncured resistor tape against both sides of suitable wire or metal-ribbon leads; the leads are thus sandwiched between two pieces of resistor tape. These units are then given the usual heat cure, which bonds the resistor tape to the

[1] A high-temperature adhesive tape resistor, *NBS Tech. News Bull.* **35**, *100 (July 1951). Described in detail in* An adhesive tape resistor system, *NBS Circular 530, Government Printing Office, 30¢.*





Left: the recently developed precured version of the Bureau's tape resistor can be soldered or spot-welded into the circuit. The original version of the NBS tape resistor is self-adhesive, but must be heat-cured by baking the chassis after all resistors have been pressed in place. The precured resistor is made by sandwiching suitable metal leads between two uncured resistors and then heat-curing, which bonds the resistor to the leads. Over-all length is about 1¼ inches. *Right:* soldering one of the precured NBS tape resistors into place. Because no subsequent heat-curing is needed, this version of the tape resistor can be used with chassis that would not withstand curing temperatures (about 300° C.).

leads and results in resistors that may be soldered or spot-welded into the circuit.

With the new precured variation in addition to the basic press-on form, the range of possible applications of the NBS tape resistor is greatly extended. Characteristic advantages of the NBS tape resistor—compactness, stability, and high-temperature operation—are largely retained in the precured wire-lead design. Furthermore, the new resistor might well prove more economical to manufacture in quantity than other types having less desirable characteristics.

The basic NBS tape resistor is made by coating asbestos-paper tape with a mixture of carbon black or graphite, silicone resin, and solvent. Resistor dimensions are standardized at one-half inch long and about one-eighth inch wide; a variety of coating formulations have been developed to give a wide range of resistor values.

Leads for the precured tape resistor are now being made from ribbon of thin silver or silver-plated copper at NBS. Leads extending one-half inch beyond the resistor proper are used, bringing the over-all length to 1½ inches. Thickness is held to about 0.012 to 0.015 inch.

Preliminary tests indicate that the precured NBS tape resistor, when supported in air by its leads alone, will not provide the full dissipation of 0.25 watt at 200° C for which the basic resistor was designed. Further test work is now in progress, and a suitable derating curve will be worked out.

New NBS Director Appointed

DR. ALLEN V. ASTIN has been appointed* Director of the National Bureau of Standards. Formerly Associate Director of the Bureau, Dr. Astin has been Acting Director since October 1951. Dr. Astin has also been appointed a member of the National Advisory Committee for Aeronautics.

Dr. Astin has been a member of the Bureau's staff since 1932. Until 1940 he was principally concerned with dielectrics and electronics. His contributions include development of improved methods for precise measurement of dielectric constants and power factors of dielectric materials and studies of the nature of energy losses in air capacitors. He did pioneering work in the development of radio telemetering techniques and instruments and applied this work to studies of cosmic rays and of meteorological problems in the earth's upper atmosphere.

In 1940 Dr. Astin was one of the Bureau scientists doing pioneering work in proximity fuze research and development for bombs and rockets. He became chief of the Optical Fuze Section in 1943, assistant chief of the Ordnance Development Division in November 1943, and chief of the Division in July 1948. He played a major part in the development and evaluation of bar-type proximity bomb fuzes and in their introduction to service during the war. During the fall and winter of 1944–45 he served in Europe as representative of the Bureau and consultant for the Ordnance Accessories Division of the National Defense Research Committee, concentrating on proximity fuze problems. He edited the terminal three-volume Technical Report of the Ordnance Accessories Division (Division 4).

As chief of the Ordnance Division from 1948 to 1950, he supervised the Ordnance Laboratory, the Guided Missile Laboratories, and the Electronics and Tube Laboratories. When Dr. Astin was appointed Associate Director in May 1950, he assumed responsibility for the work of the Ordnance Development, Missile Development, Electricity, and Electronics Divisions as well as the Office of Basic Instrumentation.

Dr. Astin was born in Salt Lake City, Utah, on June 12, 1904. He received the B. S. degree in physics from the University of Utah in 1925. While working toward his advanced degrees at New York University from 1925 to 1928, he was a graduate assistant and instructor in physics. From N. Y. U. he obtained the M. S. and Ph.D. degrees in physics in 1926 and 1928 respectively. From 1928 to 1930 he held a National Research Council Fellowship at Johns Hopkins University, doing basic research on measurement techniques relating to dielectric materials. Between 1930 and 1932, he was a Research Associate in a program sponsored at the Bureau by the National Research Council and the Utilities Research Commission, Inc.

Honors and awards he has received include the following: National Research Council Fellow in Physics, 1928–1930; Navy Ordnance Award for Exceptional

Dr. Allen V. Astin

Patented Aug. 6, 1935

2,010,133

UNITED STATES PATENT OFFICE

2,010,133

RESISTOR

Sidney Bloomenthal, Merchantville, N. J., assignor to Radio Corporation of America, a corporation of Delaware

No Drawing. Application November 25, 1933, Serial No. 699,707

16 Claims. (Cl. 201—76)

My invention relates to resistors and more particularly to resistors of types suitable for use in radio receivers, wherein noise occasioned by variations in resistance during the passage of current therethrough must be minimum.

Resistors of types used in radio receivers must be "quiet". That is to say, since such resistors are usually utilized in connection with sensitive thermionic devices, their resistance must not fluctuate while they are conducting electric currents. This requirement must be met to a greater or less degree in the manufacture of all resistors of the types under discussion.

A resistor for use in radio receivers should also have a substantially zero temperature coefficient of resistance and a low load-coefficient of resistivity. That is to say, it should be so made that temperature changes occasioned either by atmospheric conditions or by the passage of electric current therethrough will not materially affect the resistance value.

It is, accordingly, an object of my invention to provide a new and improved resistor that shall be substantially free from noise when used in an amplifier.

Another object of my invention is to provide a resistor that shall have a substantially zero temperature coefficient of resistance during normal operation thereof.

Another object of my invention is to provide a resistor that shall have a low load-coefficient of resistivity.

It is also highly desirable that manufacturing methods be devised and materials provided whereby quantity production of resistors having accurately predetermined values may be had. It is, accordingly, a further object of my invention to provide such methods and such material.

A still further object of my invention is to provide a new resistor material capable of being molded into any desired shape with full assurance that the resulting device will have the predetermined resistance and temperature coefficient characteristics.

The foregoing objects and other objects ancillary thereto I prefer to accomplish, in short, by first coating particles of a filler material, such as asbestos, powdered glass, sand, or the like, or a mixture of filler materials, with a polymerizable resin in solution and thereafter causing conducting material, preferably graphite and/or carbon black, to be precipitated upon the coated particles from a colloidal solution thereof.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment.

Substantially all fixed resistors used in radio receivers, amplifiers, and the like, include a filler, a conducting material, a binder, and a moisture-repellent impregnating material. The electrical and mechanical properties of the resistor depend not only upon the nature of these components but on the manner in which they are put together.

Previous to my present invention, I made many experiments in the effort to utilize asbestos, glass, or sand singly as well as various mixtures of sand or glass and asbestos, as fillers. For a binding material, I tried many grades of phenol formaldehyde resin in liquid and powdered form or in the form of varnish. For the conducting material, I tried dry graphite and carbon black, but in all of my early experiments I found that, if the conducting material was first mixed with the filler and the binder thereafter added, the resistors made from such a compound were extremely variable in resistance value and could not accurately be reproduced by factory processes.

According to my invention, therefore, I first take a predetermined amount of finely ground glass and air floated asbestos and intimately mix with it a solution of phenol formaldehyde resin (known as bakelite) in acetone. The principal function of the ground glass is to impart to the finished resistor a rough surface to which paint and sprayed metallic terminals will firmly adhere. For the mixing process, I prefer to use a device commercially known as a "kneader" and continue the kneading process until substantially all of the solution is evaporated. At this stage in the process, the mass of material has a dough-like consistency and if a small portion of it is examined under a microscope, it will be apparent that every particle of the asbestos and glass is covered with a film of unpolymerized resin left by the evaporation of the acetone.

The "mix" is next removed from the kneader and is crumbled into particles which are allowed to stand until all of the solution evaporates and it becomes quite hard and brittle. The material is next placed in a ball mill, or grinder of any convenient type, and is ground until substantially all of it becomes fine enough to pass an 80 mesh screen.

While the process of grinding is being carried

on, the conducting material may well be in course of preparation. For this material, I prefer to use a colloidal suspension of carbon in water, such as the graphitic material known to the trade as "Aquadag", manufactured by the Acheson Graphite Company, a gas-carbon suspension known as "Aquablack", manufactured by Binney & Smith Company, or a suitable mixture of the two.

In view of the fact that graphite has approximately one-tenth the resistance of carbon, such as is utilized in the manufacture of aquablack, these two commercial materials cannot be interchangeably utilized in the same proportions. It is, however, desirable to use aquadag for resistor elements having relatively low resistance and aquablack or mixtures of the two suspensions, suitably diluted, for resistors having relatively high resistance.

For resistors having high resistance values, it is particularly desirable to use mixtures of graphite and carbon black made from natural gas. If graphite alone is used for such resistors, the proportion thereof is so small that the particles are quite widely separated. This condition gives rise to noise which is obviated by the presence of carbon black particles that effectively "bridge" the graphite particles.

The 80-mesh resin coated particles are next intimately mixed with the colloidal carbon suspension, which has been diluted with water to a point whereat the liquid is substantially 1% carbon by weight, by a stirring operation and, for this purpose, mixing apparatus of substantially any well known commercial type may be utilized.

For the purpose of explanation of the foregoing paragraph, it is to be understood that the term "colloidal carbon suspension" is intended to include diluted aquadag, diluted aquablack, or a diluted mixture of the two. It is also within the scope of my invention to first mix the resin coated particles with either one or the other of the first-mentioned solutions, and to thereafter mix or add the other solution, thus causing successive precipitation of carbon in different forms on the particles.

Under usual conditions of manufacture, the introduction of the resin-coated filler material into the colloidal carbon suspension disturbs the electric charge relations existing in the said suspension, with the result that the carbon is precipitated onto the filler material and forms a conductive film over the entire surface of each minute particle thereof. Under certain conditions the colloidal suspension of the carbon persists and, in such case, I find it advisable to add to the mixture a small amount of hydrochloric acid which coagulates it and causes the precipitation hereinbefore mentioned. As an alternative, for the purpose of coagulating the colloidal suspension, I may add to the acetone solution of the resin, before coating the filler particles therewith, a small amount of furfural or of some other volatile material such as acetic acid, having an ionizable hydrogen atom with which it readily parts. For this purpose, I have also obtained fairly good results with small quantities of an organic acid such as malic, citric, tartaric, or the like.

After the carbon is precipitated onto the filler material particles, the supernatant liquid is either drained off or the solution is filtered in a filter press or the like. The cake resulting from the filtering process is dried at a temperature of approximately 40° C., for 24 hours, or, at least, for a period of time sufficient to drive off substantially all of the residual moisture.

In order that the continuity of the carbon film on the filler particles shall not be interrupted, the dried cake must be handled rather carefully. In other words, it is highly inadvisable to subject the cake to any further grinding operations to prepare it for handling, and at this point in the process it is found best to manually crumble the cake into small particles suitable for charging a molding machine.

The crumbled material is next loaded into the hopper of an automatic "pill" making machine, such as is used in the drug industry, or into equivalent well-known apparatus, which forms it into cylindrical rods under a pressure of the order of ten tons per square inch. For the sake of uniformity, I prefer to form rods ¾" in length and ¼" in diameter if the power rating thereof is not to be in excess of one watt. The rods made as described are then placed in trays and baked in an oven at 170° C. for approximately one hour.

I am not, at this time, prepared to exactly explain all of the physical changes caused in the pill by the baking process and consequent polymerization of the resin coating underlying the carbon on each particle of filler.

It appears, however, that during the baking step of the process, the carbon films on the particles merge together to provide what might be termed a "honeycomb" structure, of conducting material, and that the polymerization of the binder serves to lock the elements of the said honeycomb structure firmly in place, without disturbing the continuity of the carbon contacts. However, in view of the fact that the carbon films are extremely thin, it is, of course, probable that some of the resin may seep through them and bond with resin from other particles. As a matter of fact, the binder does not appear to have any pronounced insulating action and it may well happen that the theory first above given is correct.

In order that my disclosure shall be complete, the following specific directions for making 1000 resistors, each having a resistance of 700 ohms and each capable of dissipating one watt, are given:

For the above purpose, I take 5 lbs. of glass ground to pass a 150 mesh screen, 2¼ lbs. of air-floated asbestos, and mix them in a kneader with 1.62 lbs. of phenol-formaldehyde resin dissolved in 8 lbs. of acetone.

To coat the amount of filler material specified, in order to obtain the desired resistance characteristic, requires .126 lbs. of graphite. This weight of graphite is contained in .63 lbs. of commercial aquadag which is diluted by adding to it approximately 5½ pints of distilled water to form a colloidal suspension having the required density.

The following table gives relative proportions of filler, resin, and carbon for a number of finished resistors ¾" long and ¼" in diameter:

Asbestos	Resin	Graphite	Carbon black	Glass	Resistance
Percent	*Percent*	*Percent*	*Percent*	*Percent*	
72	25	3	----------	--------	700 ohms.
73	25	2	----------	--------	2000 ohms.
74	24.5	1.5	----------	--------	500000 ohms.
24	18	.7	2.3	55	1.2 megohm.
24	18	1.2	2.3	54	17000 ohms.
24	18	1.4	2.3	54	11000 ohms.

From the foregoing table, it will be apparent

that a resistor having any desired resistance characteristics may be made by suitably choosing the relative amounts of filler and conducting material. It will also be noted from the table that the variation in the resin content plays a very minor part in the resistance of the finished article, which is in accordance with the theory hereinbefore advanced.

After baking, the resistor rods must, of course, be provided with suitable terminals. For this purpose, I find it best to utilize the Schoop metal spraying process and I apply to each end of the resistor a ring of copper or tin extending inwardly from the end a distance of $\frac{3}{16}$''. Obviously, the resistance of the rod measured from end to end can be further controlled at this point in the process by adjusting the width of the sprayed terminals. As a general rule, however, this is not done in the factory, for the reason that it is much more convenient to so arrange the spraying machinery that all resistors are provided with terminals of the same width.

After the terminals have been sprayed onto the ends of the rods, the rods are immersed in a moisture-repellent impregnating material such as melted carnauba wax, aerclor, halowax, sincera wax, cerawax, paraffin, linseed oil, or the like, which has no solvent action on the polymerized resin at any operating temperature. The melted wax is preferably maintained at a temperature of 170° C., and the rods are kept therein for approximately forty five minutes. Carnauba wax is particularly advantageous to use as the impregnating material since, by reason of its expansion within the interstices of the resistor rod, at temperatures below its melting point, it compensates, to some extent, for changes in resistance occasioned by temperature rise. I have also found linseed oil to be quite satisfactory, since it oxidizes and forms a surface coating which is thoroughly waterproof. Linseed oil, however, necessitates an extra baking step to effect this oxidation.

A resistor manufactured according to my improved method offers many advantages not heretofore obtained. In the first place, the process utilizes carbon which can be purchased in its processed form and is immediately available. Secondly, the resistance values can be duplicated fairly accurately and, in addition, the electrical characteristics can be accurately determined and controlled, while the finished resistors exhibit extremely low load coefficients of resistivity. Naturally, I am aware that certain of the mentioned advantages have been approached in the past, but it is my belief that no resistor now on the market exhibits them to as great an extent as a resistor manufactured according to my improved process.

Although I have disclosed herein certain specific proportions of filler, resin, and conducting material, these are given merely by way of example and are not to be construed as in any way circumscribing the scope of my invention. Many other modifications will be apparent to those skilled in the art and my invention, therefore, is not to be limited except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. An as element of a resistor device, a particle of inert, substantially non-conductive filler material, a coating of insulating material thereon, and a film of conducting material upon the outer surface of the insulating material.

2. As an article of manufacture, a resistor composed of particles of inert filler, substantially all of said particles being respectively coated with an insulating material carrying an outer film of conducting material, the films of conducting material being in intimate contact with each other throughout the mass of said resistor.

3. The invention set forth in claim 2, wherein the insulating material is a polymerized phenol formaldehyde resin.

4. The invention set forth in claim 2 wherein the conducting material films are bonded together into a quasi-honeycomb structure.

5. The process of manufacturing a material from which resistors may be formed which comprises coating a plurality of particles of inert material with an insulating layer and thereafter depositing a conducting surface film upon substantially all of said particles.

6. The process of manufacturing a material from which resistors may be formed which comprises coating the surface of a plurality of particles of inert filler material with a polymerizable material, and thereafter causing a film of conducting material to be deposited upon the surface of the polymerizable coating.

7. The method of manufacturing a material from which resistors may be formed which comprises mixing a mass of inert material particles with a solution of a polymerizable material in a volatile solvent, causing the solvent to evaporate and then applying to the surface of substantially all of said particles an adherent coating of conducting material.

8. The invention set forth in claim 7 characterized in that the inert material is a mixture of asbestos particles and ground glass.

9. The method of manufacturing a material from which resistors may be formed which comprises moistening a mass of air-floated asbestos with a solution of a phenol formaldehyde resin in a volatile solvent, causing the solvent to evaporate, mixing the residuum with a colloidal suspension of carbon, causing the carbon to be precipitated from the suspension onto the surfaces of substantially all of the particles of asbestos, and thereafter removing the remaining solute.

10. The method of manufacturing fixed resistors which comprises intimately mixing a mass of comminuted inert filler material with a solution of phenol formaldehyde resin in a volatile solvent, causing the solvent to evaporate whereby the resin is deposited as a coating upon the particles of filler, mixing the coated particles with a colloidal suspension of carbon, causing the suspension to coagulate to thereby precipitate the carbon onto the surfaces of the particles, removing the surplus vehicle of the suspension, molding the residuum into appropriate shapes, and thereafter baking the molded articles at a temperature sufficiently high and for a sufficient length of time to cause the resin to polymerize.

11. The invention set forth in claim 10 characterized in that the inert filler material is asbestos and ground glass.

12. The method of manufacturing a material from which resistors may be formed which comprises moistening a mass of inert filler particles with a solution of phenol-formaldehyde resin and a reagent capable of causing the coagulation of a colloidal suspension of carbon in a volatile solvent, causing the solvent to evaporate, and introducing the resin-coated filler particles into a colloidal suspension of carbon.

13. The method of manufacturing a material from which resistors may be formed which comprises moistening a mass of inert filler particles with a solution of phenol-formaldehyde resin and furfural in a volatile solvent, causing the solvent to evaporate, and introducing the resin-coated filler particles into a colloidal suspension of carbon.

14. The method of manufacturing a material from which resistors may be formed which includes moistening a mass of inert filler particles with a solution of a phenol formaldehyde resin and an organic acid dissolved in acetone, causing the solvent to evaporate, and introducing the resin-coated filler particles into a colloidal suspension of carbon.

15. A resistor element in the form of a rod constituted by a plurality of particles of inert filler, substantially all of said particles having a first coating of an insulating material and an outer coating of graphite and carbon black, the said particles being in such intimate contact with each other that a substantially uninterrupted electrically conductive path is established between the ends of the rod.

16. The method of manufacturing a resistor which comprises coating each of a plurality of particles of inert filler with polymerizable resin, superimposing a film of conducting material upon the resin coating, compressing the filmed particles into a coherent mass, polymerizing the resin coating to lock the particles in place and thereafter impregnating the mass with a moisture repellent material incapable of dissolving the polymerized resin at temperatures encountered during ordinary use of the resistor.

SIDNEY BLOOMENTHAL.

EXHIBIT F

ASBESTOS

Asbestos is used in many varied forms such as board, cloth, fiber, rope packing, sleeving, tape, twine, yarn, sheet, and in other numerous combinations. The manner of storage depends upon the form of asbestos. Where the asbestos may possibly be in a loose form during storage, a dusty condition could be produced and proper ventilation should be provided.

PROPERTIES

FIRE - Non-flammable.

EXPLOSION - Non-explosive.

BREATHING - Dust from asbestos materials may produce a chronic lung disease if it is breathed in sufficient concentrations over a period of years. In some persons, the disease may develop much more rapidly than in others. The concentration and particle size of the dust will also influence the number of years of exposure required to produce the disease. In any case, exposure even to high concentrations of asbestos dust for a period of a few days or even a few months will not produce the disease. Particles larger than about 10 microns (0.000039 in.) cannot get into the small lung air sacs to cause damage. Such small particles are far below the size which is visible to the naked eye. Most dusts, however, have particles of a large range of sizes which vary from visible to invisible. It is only the fine invisible dust particles that are effective in producing asbestosis.

Where people may breathe the dust, the Maximum Allowable Concentration is 5 million particles per cubic foot of air, unless the exposure is for less than one hour per day, in which case a slightly higher concentration may be permitted but must not exceed 10 million particles per cubic foot. These Maximum Allowable Concentrations apply to repeated or recurring daily exposures. Where asbestos may be mixed with other less harmful dusts, the concentration of asbestos dust will be the controlling factor. The asbestos dust concentration can be determined by collecting and analyzing air samples.

SKIN IRRITATION - Asbestos is usually not a skin irritant.

PERSONAL PROTECTIVE EQUIPMENT

WHEN IT IS NECESSARY TO WORK IN AN AREA CONTAINING HIGH DUST CONCENTRATIONS, AN AIR-LINE RESPIRATOR OR HOSE MASK WITH OR WITHOUT A BLOWER MAY BE USED. The air-line respirator should have 8 to 15 lbs/sq.in. pressure. Care should be taken so that contaminated air does not enter the hose for the hose mask.

For medium dust concentrations, the standard all dust respirator 8883-5, equipped with filter 8883-6, may be used. Filters should be replaced according to a predetermined schedule or at any time breathing becomes difficult.

All respirators and replacement parts should have the Bureau of Mines approval which is indicated by a label on larger parts or BM#_____(approval number) on smaller parts.

PRECAUTIONS

A PERSON SHOULD NOT ENTER AN AREA CONTAINING AN EXTREMELY HIGH CONCENTRATION OF ASBESTOS DUST FOR A PROLONGED PERIOD OF TIME WITHOUT ADEQUATE PROTECTION. THE MAXIMUM ALLOWABLE CONCENTRATION

Printed in U.S.A.
1-2-53
EAST PITTSBURGH, PA.

ASBESTOS (Continued)

OF 5 MILLION PARTICLES OF DUST PER CUBIC FOOT OF AIR SHOULD NOT BE EXCEEDED FOR REPEATED OR CONTINUOUS EXPOSURES. THIS MAY BE ACCOMPLISHED BY COMPLETELY ENCLOSING THE SYSTEM OR BY PROVIDING ADEQUATE VENTILATION. PROPER PREPLACEMENT AND PERIODIC PHYSICAL EXAMINATIONS SHOULD BE MADE BY THE MEDICAL DEPARTMENT ON PERSONS WHO WORK WHERE THERE IS REPEATED OR RECURRING EXPOSURE TO ASBESTOS DUST.

WHEN IN DOUBT
CONSULT MEDICAL OR SAFETY DEPARTMENT

Westinghouse

DN 65711AA-AJ - PD SPEC (PDS) -
RL Rev W
DA Mar 5, 1978

TI CABLE, ASBESTOS INSULATED

CA CAUTION: CUTTING OR MACHINING WILL PRODUCE ASBESTOS DUST. DUST SHALL NOT BE BREATHED. ADEQUATE LOCAL EXHAUST VENTILATION SHALL BE PROVIDED. SEE SPDS A-20.

SU SUPPLIERS:

(65711AA)		A-B-D-E-F-G
(65711AB)		A-B-C-D-E-F-G
(65711AC)		C-D
(65711AJ) (All Plants except Elevator)		A-B-D
(Elevator)		A-B-D-H

(A) Carro Wire and Cable Co (Cerro) 550 Nicoll St, New Haven, CT 06504
(B) Coleman Cable Co, 1900 N Fifth Ave, River Grove, IL 60171
(D) Continental Wire and Cable Corp (Anaconda) Delben Rd, York, P 17404
(E) Okonite Co, PO Box 340, Ramsey, NJ 07446
(F) Phelps Dodge Cable and Wire Co, Foot of Point St, Yonker, NY 10702
(G) Radix Wire Co, 25252 Lakeland Blvd, Cleveland, OH 44132
(H) United States Steel Corp (Wire and Cable Div) Bullard St, Worchester, MA 01607

OR ORDER FROM SUPPLIER AS: Cable (or Wire), stating P D Spec Number and Rev Letter.

CH CHARACTERISTICS:

Grade	Previous Grade	Users	Insulation	Treated Braid
65711AA	7419-2	BG BS EP JC MAR SSD	VC & Asb	Asb§
65711AB	7419-3	BG BS EP JC LAE PT PTE SH	Asb	Asb§
65711AC	7419-4	ME	Asb	Asb
65711AD	7419-5		Obsolete.	
65711AE	7419-8		Obsolete.	
65711AF	7419-12		Obsolete.	
65711AG	7419-15		Obsolete.	
65711AH	7419-16		Obsolete.	
65711AJ	7419-1	BE BG BS EP JC ME SSD	VC & Asb	Cotton§

03144216

[redacted]

Grade	Braide Color	Type	Voltage*
65711AA	Black	AVK	600
65711AB	Black	AIA	600
65711AC	Black	AIA	600
65711AD			
65711AE			
65711AF			
65711AG			
65711AH			
65711AJ	Gray	AVB	600

Tinned copper wire, except 65711AB has untinned conductor
* Unless otherwise specified.
# Contains fungicide.
Circuit voltage, phase to phase.

AP APPLICATION:
(65711AA,AJ) Switchboard and control wiring.
(65711AB,AC) Appliance leads; general use.

CP CORPORATE PART NUMBER: PDS No. + Size Code
Example: 65711AA8ML (CABLE - If reference name is desired)

FSCM 72800

Pg 2, PDS 65711AA-AJ
Rev B : Mar 5, 1976

03144217

DN [redacted] - PD SPEC (PDS) -
RL Rev A
DA Jul 5, 1976
-
TI ASBESTOS TAPE, WOVEN
-
CA CAUTION: DUST RESULTING FROM HANDLING OR MACHINING SHALL NOT BE BREATHED. USE ONLY WITH ADEQUATE LOCAL EXHAUST VENTILATION. SEE SPDS A-20.
-
SU SUPPLIERS:
(A) Amatex Corp, 1030 Stanbridge St, Norristown, PA 19404
(B) Atlas Textile Co, 538 Walnut St, North Wales, PA 19454
(C) H K Porter, Inc, 1000 Seaboard St, Charlotte, NC 28206
(D) Raybestos-Manhattan, Inc, 100 Oakview Dr, Trumbull, CT 06611
(E) Uniroyal, 1230 Ave of Americas, NY, NY 10020
-
(.010" thk) A-B-E
(.015", .025" thk) A-B-C-D-E
-
OR ORDER FROM SUPPLIER AS: Tape, P D Spec 41511AA Rev A.
-
CH CHARACTERISTICS: (Previous 1598) (Users: BM EP JC MAR PT SH) Closely woven, unsized asbestos tape, .010", .015" and .025" thk. Tape .015" thk and over is constructed of asbestos yarns, both warp and fill, which may contain 20% (max) cotton. Tape .010" thk contains in addition to asbestos warp yarns two cotton threads at each edge and filler is of fine cotton yarn. Cotton content of asbestos warp threads is approx 17% and total percentage of cotton is approx 27%.
-
For additional properties and construction details see PDS.
-
TL TOLERANCES: See PDS
-
EQ EQUIVALENTS(ref only): MIL-I-3053, tape. grade U.G., type 2PU
-
TRADENAMES: MIL I 3053 GR U G TYPE 2PU
-
AP APPLICATION: Taping TI 130 armature coils.
-
CP CORPORATE PART NUMBER: PDS No. + Size Code
Example: 41511AA1BM (ASB TAPE - If reference name is desired)

DN 42231AA-AB - PD SPEC (PDS) -
RL Rev D
DA Jan 20, 1977

TI ABESTOS PAPER

CA CAUTION: DUST RESULTING FROM HANDLING OR MACHINING SHALL NOT BE BREATHED. USE ONLY WITH ADEQUATE LOCAL EXHAUST VENTILATION. SEE SPDS A-20.

SU SUPPLIERS:
(42231AA) Johns-Manville, Greenwood Plaza, Denver, CO 80217

OR ORDER FROM SUPPLIER AS: (42231AA) Paper, P D Spec 42231AA Rev D.

CH CHARACTERISTICS: 42231AA (Previous 4262-1) (User: BM BMM CL EP M&R TM) High grade asbestos paper composed of nonferrous type asbestos fiber specially manufactured to be free from conducting particles. It is much freer from conducting particles than commercial asbestos paper 42331AA and is considerably more expensive.

Thk, Inch.	Tens Str, Min (Lb/In Width)		Tear Str, Min (Gm/In. Width)		Apparant Density Grams/cc		Basis Weight, Lb/100 Sq Ft	
Nom	MD	CMD	MD	CMD	Min	Max	Min	Max
0.005	12	7	20	28	.65	.91	1.7	2.3
.0065	15	9	28	39	.76	.89	2.4	3.1
.007	17	10	29	40	.69	.95	2.9	3.5
.010	20	12	40	47	.67	.92	3.6	4.8
.015	23	13	62	77	.69	.94	5.5	7.5

42231AB (Previous 4262-2) Obsolete.

TL TOLERANCES: See PDS

EQ EQUIVALENTS(ref only): MIL-I-3053, type 2PU
TRADENAMES: MIL I 3053 TYPE 2PU QUINORGO 4000

AP APPLICATION: Treated with shellac for field coil insulation.

CP CORPORATE PART NUMBER: PDS No. + Size Code
Example: 42231AA18Q (ASB PAPER - If reference name is desired)

EXHIBIT G

Asbestos Exposure Causes Mesothelioma, But Not *This* Asbestos Exposure:

An Amicus Brief to the Michigan Supreme Court

LAURA S. WELCH, MD*

Manufacturers of asbestos brakes, supported by many manufacturing and insurance industry *amicus curie*, requested the Michigan Supreme Court to dismiss testimony of an expert regarding the ability of asbestos dust from brakes to cause mesothelioma as "junk science." Scientists are concerned with the sweeping and unequivocal claims that any conclusion that asbestos from brakes caused a signature asbestos-related disease in a particular person must be "junk science." The manufacturers' sweeping pronouncements are what veer from accepted, reliable mainstream scientific methods and conclusions. This article outlines the evidence supporting the conclusion that asbestos from brakes can and does cause mesothelioma, and describes the defendants' attempts to fabricate doubt about this conclusion. *Key words:* asbestos; brakes; chrysotile; mechanic; occupation; epidemiology; mesothelioma.

INT J OCCUP ENVIRON HEALTH 2007;13:318–327

Companies that made and sold asbestos-containing brakes asked the Supreme Court of Michigan to effectively rule that it is impossible to contract asbestos-related diseases as a result of exposure to asbestos from asbestos brakes.† As physicians and scientists, we are concerned about the epidemic of asbestos disease that continues to cause the deaths of thousands of workers each year in the United States. The signers of this paper represent hundreds of years of experience researching, diagnosing, and treating asbestos-related diseases in workers and their families. We have published extensively in this field for more than 30 years and have conducted dozens of epidemiologic and other studies into the issues of asbestos and disease. Many of us have testified before legislative and regulatory bodies regarding asbestos and disease and in court proceedings at the request of individuals suffering from mesothelioma and other asbestos-related diseases.

We make no claim to know the "correct" answer to disease causation in the specific case under review in the court. Our concern is with the sweeping and unequivocal claim that any conclusion that asbestos from brakes has caused a signature asbestos-related disease in a particular person must be "junk science." We find that sweeping pronouncement itself is what veers from accepted, reliable mainstream scientific methods and conclusions.

Ample Evidence Supports the Conclusion That Asbestos from Brakes Can and Does Cause Mesothelioma

Chrysotile causes cancer, including mesothelioma. "There is general agreement among scientists and health agencies . . . [e]xposure to any asbestos type (i.e., serpentine [chrysotile] or amphibole) can increase the likelihood of lung cancer, mesothelioma, and nonmalignant lung and pleural disorders."[1]

Many other reviews support this conclusion, such as those from the American Conference of Governmental Industrial Hygienists,[2] the American Thoracic Society,[3] the Environmental Protection Agency,[4] the International Agency for Research on Cancer,[5] the National Toxicology Program,[6] the Occupational Safety and Health Administration,[7] the Consumer Products Safety Commission (CPSC),[8] the World Health Organization,[9–11] and the World Trade Organization.[12] This scientific consensus is also reflected in the Consensus Report of the 1997 Helsinki Conference,[13] and publications from the American Cancer Society[14] and the National Cancer Institute of the National Institutes of Health.[15]

Thorough scientific inquiry requires consideration of all available information. Accordingly, in reaching the conclusion that chrysotile asbestos causes mesothelioma, scientists properly consider numerous accepted sources of scientific data, including epidemiologic studies of all varieties, case reports and series of case reports, controlled animal experiments, and toxicologic studies.[1,16–23]

Asbestos industry arguments to the contrary have not been supported over time. Chrysotile asbestos mining companies and manufacturers have argued for more than 30 years either that their products do not cause disease or that there is insufficient evidence to reach a reliable conclusion. Numerous scientific articles and criticisms have specifically exposed the artificial uncertainty cre-

*Dr. Welch is joined by 51 other signers onto this communication; see end of document.

†*Chapin v. DaimlerChrysler Corporation et al.*, Case No. 133178, Supreme Court of Michigan.

Address correspondence andreprint requests to: Laura S. Welch, MD, Medical Director, Center to Protect Workers Rights, 8484 Georgia Avenue, Silver Spring, MD 20910, U.S.A.

ated by the proponents of chrysotile asbestos, and their position has been repeatedly and consistently rejected by the mainstream scientific and regulatory communities.[18–20,24–26]

Like many scientists, we are concerned with the development and expansion of "doubt science."[27,28] A centerpiece of the "doubt science" model is the assertion that whatever piece of evidence supports the position of the industry in question (or whatever piece of evidence might be as yet undetermined) is *the* critical piece of evidence, to the exclusion of all others. While we acknowledge that industry-sponsored research can and does often provide valuable scientific insight and developments, the efforts of the tobacco and asbestos industries to deny their products cause cancer have become a paradigm for "doubt science."

In this regard, we are cognizant of the fact that the primary articles upon which the asbestos brake manufacturers rely in this matter were paid for by Ford, General Motors, Chrysler and other asbestos brake manufacturers. Publications by Hessel,[29] Goodman,[30] and Paustenbach[31,32] were all expressly funded by Ford, General Motors, and Chrysler. Furthermore, the paper by Hessel et al. appeared in a journal funded by the Ford Motor Company and a subsidiary of General Motors. Wong[33] has been reported to have undisclosed origins as an expert witness report for a brake manufacturer.[34] Laden acknowledges funding by a law firm that is "national asbestos counsel" for another asbestos brake manufacturer.[35]

The Scientific Community is in Consensus that Even Brief and Low-level Exposure to Asbestos Can Cause Mesothelioma

The mainstream scientific community has long recognized and continues to recognize today that there is no "safe" level of exposure to asbestos.[12,13] As noted by NIOSH:

> Excessive cancer risks have been demonstrated at all fiber concentrations studied to date. Evaluation of all available human data provides no evidence for a threshold or for a "safe" level of asbestos exposure.[36]

Attempts to postulate thresholds for exposure have been dismissed as "logical nonsense."[37]

The lack of a defined "safe" level for exposure to asbestos has been supported by subsequent research. For example, a large French study recently concluded that substantial excess mortality occurs at exposure levels below current regulatory levels.[38] A recent study examining the relationship between historical asbestos use and disease rates further supports the conclusion that a linear dose–response relationship exists between exposure to asbestos and disease and that no "safe" level of exposure exists.[39]

One of the main studies upon which the asbestos brake manufacturers rely[40] similarly concluded that *all* levels of occupational exposure to asbestos increase the risk of mesothelioma:

> Compared to those who never worked or who were never exposed, all levels of probability and intensity [of exposure to asbestos] had an increased significant risk, except subjects with low probability of exposure. For exposure classified as "sure" the OR was 13.2.

Application of this study to the current case under review would result in his placement in the "sure" exposure category, and consequently he would be over 13 times more likely to contract mesothelioma than unexposed individuals. Despite this, the asbestos brake manufacturers assert that the Agudo study proves that no person can ever get mesothelioma from asbestos brakes. That argument is unsound and contrary to the consensus of the scientific community that there is no demonstrable threshold of exposure to asbestos below which adverse health effects do not occur. Accordingly, "an occupational history of brief or low-level exposure should be considered sufficient for mesothelioma to be designated occupationally related" to asbestos exposure.[13]

Mesothelioma Is a Signature Malignancy for Asbestos Exposure

There is no debate that asbestos causes mesothelioma, and that the great majority of mesotheliomas are demonstrably caused by asbestos.[41] Some mesotheliomas are never able to be individually linked to asbestos exposure, and the scientific community has defined these cases as "idiopathic" because information regarding asbestos exposure is unavailable.

However, we know that many individuals do not know that they have been exposed to asbestos.[42] Many more die before being interviewed regarding potential exposures, forcing researchers to make assumptions about exposure based upon information from next of kin, job titles, or death certificates; these sources often fail to reflect all jobs and exposures.[43,44] Many epidemiologic studies assess occupational exposure but not para-occupational or environmental exposure, because only occupational information is available from existing records. The fact that a percentage of mesotheliomas are labeled "idiopathic" does not, however, support the conclusion that there are large numbers of spontaneous (i.e., non–asbestos-related) mesotheliomas. To the contrary, a large study of numerous sources of information failed to demonstrate evidence for "spontaneous" mesotheliomas,[45] and a detailed review of mesothelioma cases in Australia found that over 90% had either a history of exposure or substantial asbestos in lung tissue.[42]

The asbestos brake manufacturers attempt, without support, to recast the definition of "idiopathic." First,

in an attempt to undercut the indisputable link between asbestos and mesothelioma, they suggest that "idiopathic" mesotheliomas are not caused by asbestos rather than accepting that these are cases where individual exposure has not been identified. Second, they attempt to place mesotheliomas with demonstrable occupational exposures to asbestos—specifically asbestos from brakes—in the "idiopathic" category. There is no scientific support for either position.

Mesothelioma is a signature tumor for asbestos exposure. Individuals with known occupational exposures to asbestos cannot be recast into the "idiopathic" or "unknown exposure" category. When confronted with an individual who has a demonstrated mesothelioma and demonstrated occupational exposure to asbestos, the mainstream scientific community recognizes that the cause of that mesothelioma is the asbestos exposure of the individual even if that exposure was "brief or low-level."

Because Mesothelioma Is a Signature Malignancy with Essentially One Cause—Asbestos—the Scientific Community Has Long Considered Individual Cases of Mesothelioma to Be Sentinel Events

It is not necessary to have an epidemiologic study of a specific occupation to be able to conclude that an individual's exposure to a toxic substance in that occupation can be a cause of disease. To the contrary, as noted by Dr. Lemen,

> Specific occupations do not need to be studied nor do epidemiological studies need to be performed to show risk of disease before prevention actions are taken or causal connections concluded. To wait for epidemiology studies of each occupational group is not warranted but has been taken by many in the medico-legal profession as the only way to prove causation by occupation. Such misconceived thinking has been very harmful to the future prevention of asbestos-related diseases.[46]

This is particularly so when examining mesothelioma. Repeated studies have shown that all levels of exposure increase the risk of mesothelioma.[38,40] Moreover, unlike many other cancers, for which there are multiple, well-documented causal factors, mesothelioma is overwhelmingly caused by asbestos. As noted by one of the studies upon which the asbestos brake manufacturers rely:

> Mesothelioma is a rare cancer with one major etiologic exposure, therefore surveillance using each case as a sentinel event might seem more reasonable for this disease than for cancers with multifactoral causation.[47]

In 1983 Rutstein developed a list of sentinel health events (SHE-O) that are occupationally related.[48] Mesothelioma as a sentinel disease for asbestos exposure was on the initial list of SHE-O, and all subsequent revisions. In fact, the worldwide acceptance of mesothelioma as an asbestos-related cancer began with the case series published by Wagner in 1960.[49]

When examining the question of causation of sentinel diseases such as mesothelioma, the scientific community recognizes that case reports and case series reports are useful and valid tools.

> Case series are particularly informative in situations where there are identified occurrences of very rare conditions for which there are few, if any, established causal factors. . . . In fact, recognition of even a small number of cases of the "sentinel" diseases—such as liver angiosarcoma and malignant mesothelioma, which is strongly related to asbestos exposure.[50]

The scientific community has concluded that, for sentinel diseases such as mesothelioma, case series reports can be sufficient by themselves to allow reliable conclusions to be drawn regarding causation. Again, as noted by Checkoway:

> Case series reports can be virtually conclusive in their own right when the health outcome is a very rare disease or an uncommon manifestation of a relatively common condition.[50]

We do not suggest that such conclusions are indisputable or inviolate; scientific knowledge rarely is. The relevant question is whether reliable and scientifically justifiable conclusions can be drawn based upon such information, when considered in connection with all other available evidence. They can. In fact, proper application of the scientific method requires consideration of all forms of available evidence.

Accepted Method for Evaluating Disease Causation in an Individual: Generally and as Applied to Asbestos Exposure and Mesothelioma

Examining the question of causation of disease in an individual generally involves four questions: 1) was the individual exposed to a toxic agent 2) does the agent cause the disease present in the individual; 3) was the individual exposed to this substance at a level where disease has occurred in other settings; and 4) have other competing explanations for the disease been excluded?

There is no reasonable dispute regarding Question 2—asbestos causes mesothelioma. Additionally, there are no well-accepted competing explanations regarding mesothelioma that must be excluded, resolving Question 4. As a result, when considering the issue of causation of a mesothelioma, once an occupational or para-occupational exposure to asbestos has been established (Question 1), the sole question remaining for

examination is whether the exposure or set of exposures of that individual is similar to exposures that have been documented to cause mesothelioma in others—Question 3.

The mainstream scientific community is in consensus regarding the resolution of Question 3. As discussed above, there is no safe level of exposure to asbestos. Even exposure at current regulatory levels results in excess mesotheliomas.[7,38] Accordingly, the consensus of the scientific community is that any occupational or para-occupational exposure to asbestos—even "brief or low-level exposures"—must be considered causal in an individual with a mesothelioma.

The Claim of the Asbestos Brake Manufacturers That the Studies upon Which They Rely Trump All Other Scientific Knowledge Is Scientifically Unsupportable.

The asbestos brake manufacturers cite a number of epidemiologic studies as proof that asbestos from brakes cannot cause mesothelioma. The manufacturers claim the fact that these studies did not detect a statistically significant increased risk of mesothelioma in the occupational groups studied is conclusive proof that no person can ever contract disease from working with asbestos brakes.

That claim is simply not scientifically supportable. We need not examine here the individual shortcomings of the studies relied upon by the asbestos brake manufacturers. Others have done so cogently and in detail.[16,34] While our rejection of the asbestos brake manufacturers' sweeping claim is supported by these critiques, the fundamental scientific failing of their claim is not based on the obvious limitations of the individual studies. There is a difference between a truly negative result and a non-positive result. A true negative study must be large, sensitive, and contain accurate exposure data. Even then, the study will be negative only with respect to the exposure level studied. Far from proving that no person can ever get sick from asbestos dust released by brakes, the best that can be said for the studies is that they are inconclusive. Instead, such a claim is based on the scientifically unsupportable proposition that one study, or group of studies, trumps all other evidence, no matter how extensive and well-documented that evidence is. Additional discussion of the implication of "negative" epidemiologic studies may be found elsewhere.[51–54]

As noted above, examination of the question of whether a substance is capable of causing disease requires consideration of all scientific disciplines and all available evidence. This is particularly true when asserting that exposure can *not* cause an effect.

> The conclusion that some exposure is devoid of harmful effect (e.g. a certain chemical is not carcinogenic) must be based on a synthesis of the whole available literature: it can never rely on one single study. Hence, all the scientific evidence (i.e. theoretical experimental, and epidemiologic) that exists must be combined.[55]

Substantial insight into this issue is provided by the industry consultants hired by Ford, General Motors, and Chrysler. When hired to represent the auto industry in asbestos-brake litigation, the industry consultants assert that their cited epidemiologic studies trump all other evidence, and conclusively refute the claim that asbestos from brakes can cause mesothelioma.[29,30] Conversely, when hired by the power industry to provide testimony regarding epidemiologic studies that were damaging to that industry, Dr. Hessel rejected this same position:

> Because of such recognized limitations, epidemiology studies by themselves generally do not provide sufficient basis to support conclusions about causation. That is why the assessment of health risk must rely on data from toxicological studies in animals, studies in human cells and tissues and experimental clinical studies.[56]

The opportunistic rejection of whatever evidence exists contrary to the position of the industry being defended is a hallmark of "doubt science." We disagree with both extremes. Epidemiologic evidence may, in cases, be sufficient to make reasoned and well-founded judgments regarding causation after consideration of other available evidence, even if evidence from one or more other scientific disciplines is absent. Conversely, consideration of other scientific evidence may allow reasoned conclusions regarding causation in the absence of positive epidemiologic studies regarding a specific population.

It is unscientific for the asbestos brake manufacturers to assert that their chosen epidemiologic studies trump all other evidence, just as it was unscientific for the tobacco industry to claim that lack of understanding of the mechanism by which tobacco causes cancer made it impossible to conclude that cigarettes cause cancer. Proper application of the scientific method requires that all available evidence be considered when examining issues of causation.

Evidence Supporting the Conclusion That Asbestos from Brakes Can and Does Cause Disease, Including Mesothelioma

The danger of asbestos in brakes has been recognized for decades. The hazard from exposure to asbestos in friction products has been known and accepted for over 70 years. In 1948, General Motors' chief industrial hygienist published regarding the hazards created when manipulating asbestos brake materials in the factory.[57] By 1958, the danger of exposure to asbestos dust from brakes was sufficiently well documented that it was

included in the American Industrial Hygiene Association's Hygienic Guide series.[58] Additionally, mesotheliomas have been documented repeatedly in workers at friction-product factories.[34,59–62]

Today, the asbestos brake manufacturers assert that this danger is confined to the friction-product manufacturing facility. However, there is no scientific justification for asserting that dust from an asbestos brake can cause disease when the brake is ground in a factory but cannot cause disease when that same brake is ground in a garage.

Mechanics who work with asbestos brakes without dust-control measures are exposed to asbestos. Numerous studies have demonstrated that mechanics who worked with asbestos-containing brakes without dust-control measures were exposed to asbestos dust. This is particularly true when the mechanic grinds, files, or sands the new asbestos brake and uses compressed air or dry brushing to clean out wear dust from old asbestos brakes.[63–66] Both the EPA and OSHA have issued guidance to reduce the risk of disease from asbestos exposure during brake work.[7,67,68] OSHA requires the use of dust controls when employees work with asbestos-containing brakes and clutches (for specific details see appendix F of the standard).[7] The EPA has adopted these standards for municipal employees in jurisdictions not governed by state asbestos-control plans.[67] Other regulatory agencies have similarly issued guidance to mechanics to reduce exposures to asbestos from brakes and clutches.[69–72]

Equally important, it has been proven that use of effective dust-control measures can lower exposure levels during work with asbestos brakes.[73,74] Accordingly, to provide a reliable basis for the conclusion that asbestos from brakes can never cause disease, a study of brake mechanics would ascertain whether individuals considered "exposed" to asbestos brakes used dust-control practices. None of the studies relied upon by the asbestos brake manufacturers contains such information.

Studies have shown increased incidences of non-malignant asbestos-related diseases among mechanics known to have performed work with asbestos-containing brakes. Excessive non-malignant disease in mechanics occurs in individuals known to have worked with asbestos-containing brakes.[65,75] It is universally accepted that the amount of asbestos exposure needed to cause asbestosis is greater than the amount needed to cause mesothelioma. Accordingly, studies demonstrating excess asbestosis in asbestos brake-repair workers demonstrate that these workers were historically exposed to quantities of asbestos far in excess of that needed to cause mesothelioma.

Proper scientific inquiry cannot ignore the hundreds of reported cases of mesothelioma in mechanics. We reject the contention of the asbestos brake manufacturers that the scientist must close his or her eyes and refuse to consider case reports or case series of mesothelioma in mechanics, irrespective of how many cases are reported. This contention flies in the face of sound scientific reasoning, which *requires* thoughtful consideration of *all* available evidence.

As discussed above, the consideration of case reports is even more critical when examining rare, sentinel diseases such as mesothelioma because of the great difficulty in conducting epidemiologic studies with sufficient power to reliably detect increases in disease.[53,54] Hundreds of cases of mesothelioma in mechanics have been reported in the medical literature, including dozens of cases in the studies relied upon by the asbestos brake manufacturers.[16]

The precise number of cases is not important for purposes of our discussion, nor is the possibility that some cases may have involved exposures to asbestos from sources other than brakes. The important point is that proper scientific inquiry not only can consider these reports, but, in fact, must consider them. Contrary to the suggestion of the asbestos brake manufacturers, these cases cannot be cavalierly dismissed as "unscientific" or "insufficient to support conclusions regarding causation." When considering the important question of whether working with asbestos-containing brakes can cause incurable, inevitably terminal diseases, such as mesothelioma, case series must be considered and evaluated, along with all other available evidence.

There is nothing novel regarding the use of Sir Austin Bradford Hill's viewpoints to arrive at the conclusion that asbestos from brakes can cause disease. Application of his viewpoints has been an accepted and valid method for examination of questions of causation for decades and remains so today.[76] His own wise words are worth repeating:

> Here then are nine different viewpoints from all of which we should study association before we cry causation. What I do not believe—and this has been suggested—that we can usefully lay down some hard-and-fast rules of evidence that must be obeyed before we can accept cause and effect. None of my nine viewpoints can bring indisputable evidence for or against the cause-and-effect hypothesis and none can be required as a sine qua non. What they can do, with greater or less strength, is to help us make up our minds on the fundamental question—is there any other way of explaining the set of facts before us, is there any other answer equally, or more, likely than cause and effect?

Contrary to the all-or-nothing position of the asbestos brake manufacturers, there is no single scientific discipline or type of study that takes precedence over others. Thoughtful scientific inquiry requires consideration of all evidence when making determinations regarding causation.

CONCLUSION

Asbestos causes mesothelioma. Mechanics are exposed to asbestos dust during the servicing and replacement

of brakes. While the asbestos brake manufacturers claim that the average amount of asbestos released from brake repair work is comparatively low, there is no reasonable dispute that exposure levels were higher when mechanics routinely ground, filed, and sanded brakes and used compressed air to blow out brake wear debris, and did this work without dust control. It is those historic higher exposures that caused disease appearing now. The scientific community is in consensus that brief and low-level exposures to asbestos can cause mesothelioma. The scientific literature contains hundreds of cases of mesothelioma among brake mechanics; and epidemiologic studies of mechanics known to have performed repair work on asbestos-containing brakes have demonstrated increased levels of nonmalignant diseases.

This combination of evidence, and the vast amount of additional scientific information regarding asbestos and mesothelioma, provides more than sufficient evidence to allow someone to conclude within a reasonable degree of scientific certainty that a mesothelioma in a mechanic who worked with asbestos-containing brakes was caused by that asbestos exposure.

Since 2000, Ford, General Motors, and Chrysler have paid over $30,000,000 to hire consultants for the purpose of generating the very papers they rely upon, and for testifying regarding those papers in Courts.† One of the main industry experts has acknowledged that the papers were conceived and authored for the purpose of buttressing testimony in court cases involving mechanics suffering from mesothelioma.‡

The same expert also acknowledged that this business model is a pattern he has also followed with dioxin, benzene, hexavalent chromium, beryllium, formaldehyde, and glycol ethers. Recent revelations regarding undisclosed involvement of the employer of these experts in connection with publication of a paper favorable to the chromium industry have been well publicized and led to the retraction of that paper.[77,78] It is in no way surprising that the experts and papers financed by these manufacturers conclude that asbestos in brakes can never cause mesothelioma. To the contrary, the exoneration of the sponsoring industry is the *expected* conclusion of doubt science. Despite the best efforts of the asbestos brake manufacturers and their hired experts to fabricate scientific uncertainty where none exists, the mainstream scientific community and regulatory communities have considered the available evidence and concluded that the danger to mechanics from asbestos in brakes is real.

Apparently, the asbestos brake manufacturers hope that these arguments can be used to sway the Supreme Court of Michigan and other courts. As scientists who have devoted substantial portions of our professional lives working to research, prevent, and treat asbestos-related diseases, we reject these attempts to fabricate uncertainty where none exists. Instead, we request that these courts attend to the work of thousands of experts from around the world who have concluded that asbestos, in any form, and through any occupational exposure, can and does cause disease.

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†Ford, General Motors, and Chrysler have admitted in litigation that, since 2000, they have paid over $30,000,000 to these experts. See, Ford and General Motors, Answers to Interrogatories, *Unden v. General Motors*, Case No. 05:6311, Circuit Court for Hillsborough County, Florida, and Chrysler IRS Form 1099s produced in litigation.

‡Deposition of Dennis Paustenbach, July 1, 2005, *Mallia v. Bennett Auto et al.*, Case Number 04-16236 CA 42, CIrcuit Court in and for Dade County, Florida.

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